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VOL. 11 MAY, 1924 No. 3


## THE ALLOCATION OF WATER SUPPLIES DERIVED FROM THE WATERSHEDS OF INTERSTATE STREAMS[1]


BY LEONARD P. WOOD[2]


The problems growing out of conflicting state rights in interstate streams are not new. In one form or another they have been appearing in our eastern states for one hundred and forty years. The emphasis has changed from questions of jurisdiction and police to fisheries and navigation, including log running and rafting, to water power and water supply for canals, and more recently, to municipal water supply and its twin problem, the disposal of sewage and industrial wastes, with water power again assuming importance. In the arid regions of the West, these problems arose later and have developed much more rapidly, and from the first the emphasis has been on irrigation. This paper will be limited to those phases of the problem connected with municipal water supplies, incidental reference only being made to such of the other phases as are inextricably bound up with the development of municipal water supplies from the watersheds of interstate streams.

As indicating the nature of the problems arising in the development, for municipal water supplies, of the watersheds of interstate streams, some of the larger projects in four of the Atlantic states, Massachusetts, New Jersey, Pennsylvania and New York, will be

[1] To be presented before the New York Convention, May, 1924.

[2] Assistant Engineer, Board of Water Supply, New York, N. Y.

briefly considered. These are all well-watered states with abundant rainfall and good reservoir sites, and with their largest water-consuming metropolitan areas near the mouths of some of their largest streams; yet, because of the fortuitous proximity to these metropolitan areas of purely arbitrary state boundaries, these problems have arisen on a large scale in all. These states are discussed in the order named:

The Metropolitan Water District of Massachusetts, created in 1895, consisting of the municipalities within a ten mile radius centering on Boston, embraced for water supply purposes in 1920 a population of about 1,200,000, nearly one-third of the population of the entire Commonwealth, and used 127 m.g.d. from the Metropolitan District water system. The 1970 population and consumption are estimated at about 2,600,000 and 380 m.g.d. respectively. Considering cost, quality of water, consequences of diversion, and reservations which must be made for communities in other parts of the state, the Metropolitan District has already absorbed all sources of water supply available from watersheds wholly within the state. In fact, the waters of the Nashua river or Wachusett system, representing two-thirds of the capacity of the present works, flow for about 15 miles through the neighboring state of New Hampshire, en route to the lower Merrimac river in Massachusetts. No interstate difficulty arose in this case, a satisfactory financial settlement having been made with the mill owners and with the city of Nashua, the only community in New Hampshire adversely affected by the diversion. For a diversion made at about the same time, the City of Worcester, Mass., also effected settlement without interstate complications, with a large number of mill owners in Rhode Island, the diversion, however, being from but 1 per cent of the drainage area of the Blackstone river where that stream enters the lower state.

All important future additions to the supply of the Metropolitan District must be drawn from the watersheds of interstate streams, or from sources wholly outside the state. The comprehensive plan developed in 1893 to 1895 by the late Frederic P. Stearns, then Chief Engineer of the Massachusetts State Board of Health, and the modified plan submitted in 1922 by the Joint Board relative to Water Supply Needs and Resources of the Commonwealth, X. H. Goodnough, Chief Engineer, both contemplate drawing all future additions to the supply of the Metropolitan District from tributaries

of the Connecticut, a river the lower 65 miles of whose course lie in the neighboring state of Connecticut. No water supplies are now or are likely to be drawn from the main river in Connecticut, the principal adverse interest being water power. The unusual method of development now proposed, limiting diversion to flood flows in excess of 1.2 second feet per square mile, would seem to eliminate any possible grounds for protest by Connecticut against the proposed diversions in and by Massachusetts. Should these projects ever be carried out in their entirety, however, an important part of the problem of sanitary control would lie on the upper parts of the tributary watersheds in the states of New Hampshire and Vermont.

The metropolitan area of New Jersey embraces approximately six counties in the north-easterly part of the state, with a 1920 population of about 2,100,000, two-thirds of the population of the state, and a total water consumption exceeding 280 m.g.d. The 1970 population and consumption in the metropolitan area have been estimated by Allen Hazen at 5,600,000 and 880 m.g.d. respectively. In his admirable report[3] on the water resources of this state and their development for the supply of this metropolitan area, Mr. Hazen well says, "The water resources of New Jersey are great and conveniently situated. Taking everything into account, there is scarcely a state in the Union so favorably situated for providing the water supply of a great Metropolitan District. In saying this we have in mind the quality and accessibility of the water that can be provided; clean and soft for domestic and industrial uses, and near at hand and high enough to be delivered by gravity, or mainly by gravity, in large volumes at relatively low coasts." New Jersey is also fortunate in that one of its largest watersheds, that of the Passaic, drains to the sea through the heart of its metropolitan area, and another, that of the Raritan, along the southern margin of this area. The immediate water-supply situation in the metropolitan area is acute and numerous studies for additional supplies, in addition to those of Mr. Hazen, have recently been made. So ample are New Jersey's water resources that Mr. Hazen was able to point out sources within the state capable of development to yield more than three times the probable 1970 demand of the metropolitan area, without encroaching upon the resources necessarily to

[3] Report on Water Resources of the State and Their Development, Hazen, Whipple and Fuller, 1922.

be reserved for other parts of the state. On closer view, however, it appears that 20 per cent of this prospective supply is from tributaries of the Delaware, and 30 per cent more is to be drawn from the main stream "in the winters of dry years"; and of the new water available by gravity from watersheds wholly within the state, five-sevenths is from tributaries of the Delaware. Since the Delaware below the proposed points of diversion furnishes two-thirds of Philadelphia's present water supply, the entire water supply of other cities and towns in Pennsylvania and much of the supply of the Delaware division of the Pennsylvania canals, the interest, in any such development, of the Commonwealth of Pennsylvania, as a joint claimant to the waters of this boundary stream, is obvious.

But there are other interstate complications in the development of New Jersey's waters. The Hackensack river watershed now supplies about 30 m.g.d. and is being developed to supply about 41. As Mr. Hazen has pointed out, it can be developed up to 65 or 70 m.g.d., but only with part of the necessary storage in New York, in which state the upper half of the drainage area lies. Again, the Wanaque river watershed of 96 square miles, which is now being developed by the North Jersey District Water Supply Commission, has an important part of its watershed and about 8 miles of the shore of Greenwood lake in New York. Since the shores of this lake have a large and growing summer population of campers and cottagers, drawn by the opportunities for boating, bathing, etc., a large part of the sanitary problem of the Wanaque watershed is in the neighboring state. The Ramapo river watershed, recently studied for the City of Bayonne by Weston and Sampson, presents another interstate problem. Three-fourths of the more than 140 square miles of available drainage area, most of the villages including the only village sewered, most of the private sewers, and the only adequate reservoir site being in New York, which also has pressing water supply needs close at hand. Whereas the complete development, including a reservoir in each state, will yield 100 m.g.d. net for water supply, after allowing for necessary compensation water, storage can be developed within the state of New Jersey only sufficient to yield about 40 m.g.d. net. New York, on the other hand, having an opportunity to develop almost unlimited reservoir capacity, should it disregard New Jersey's needs, could develop for its own use something like 80 m.g.d. net, after the same allowance of compensation water. Because of the excellent character of the water,

much softer than that from more distant western sources, and because of its nearness to the centers of consumption in both states and the consequent low cost of development, failure to develop the Ramapo fully would be an economic waste; but full development by and for New Jersey appears to be impossible without some form of effective interstate coöperation.

Philadelphia had in 1920 a population of 1,824,000 and the municipal works supplied 310 m.g.d. The 1970 population and consumption have been estimated,[4] respectively, at 3,500,000 and 500 m.g.d., or 600 m.g.d., if general metering is not effected. Additional supplies for Philadelphia have been the subject of a long series of investigations by able engineers and engineering boards. Consideration has been given to many projects, some involving more than 100 miles of aqueduct through mountain country. The Mullica river in southern New Jersey, with or without contiguous streams, has been repeatedly pointed out as furnishing a large supply of excellent water within 30 to 40 miles of the city at a reasonable cost, but this project has always been dismissed as impracticable on account of the difficulties, probability of long delay and uncertainty of eventual success, in securing permissive legislation by the neighbor state.

The present supply of Philadelphia is all pumped from the Delaware river or from the Schuylkill, a tributary of the Delaware flowing through the city; two-thirds of the supply is taken from the tidal Delaware at Torresdale within the city limits and below the falls at Trenton. Though the water is filtered, increasing pollution of the river will eventually require removal of this intake to some point above Trenton, where there will be competing demands, in New Jersey, for the municipal supply of Trenton, for the supply of the Delaware and Raritan canal, and for water power.

Of the 1920 population of the State of New York, 59 per cent or more than 6,000,000 people were crowded into a small metropolitan area occupying a spur of land projecting from the extreme southeast corner of the state, between New Jersey and Connecticut. New York City alone had a population of 5,620,000 and a water consumption of 735 m.g.d. The estimated 1970 population and consumption of those parts of this metropolitan area which lack

[4] Report on Extensions and Improvements of the Present Water Works System (of Philadelphia) by J. W Ledoux, George W. Fuller, Joseph F. Hasskarl, J. Waldo Smith, September 15, 1920.

adequate local sources of water supply, exceed 13,000,000 persons and 2300 m.g.d. Until within the last twenty-five years, state boundaries presented no very serious obstacle to the development of the water supply for this metropolitan area, the main supply, supplemented by local sources, having been obtained from Long Island on the east and from the Bronx and Croton watersheds on the north, about as conveniently and as economically as it could have been obtained from interstate streams. With a single minor exception, to be mentioned later, the entire supply was obtained from watersheds wholly within the state, although many projects, dating back at least as far as 1823, had been brought forward for taking water from streams in or flowing into the two adjoining states. In the earlier discussions, it does not appear that the questions of interstate water rights were seriously raised.

About 1896, plans were discussed for supplying a part of New York City from those parts of the Ramapo and Wanaque river watersheds lying in New York State just north of New Jersey, into which state these streams flow. Interference with existing and prospective water supply developments in New Jersey and the probable adverse action of that state, were among the strongest arguments against this project. In 1900, John R. Freeman, in his classic report on New York's Water Supply strongly recommended the immediate development for New York City of the Ten Mile river and the upper Housatonic, the Ten Mile which lies in New York State, draining into the Housatonic, which is a Connecticut stream. The project was most attractive. The need for more water was urgent and on the Ten Mile an immediate supply of 150 m.g.d. could be developed by works wholly within the state, and 105 m.g.d. of this could be delivered to the city with no cost or delay for aqueduct construction, by utilizing the surplus capacity of the two Croton aqueducts above the then developed safe yield of the Croton watershed. From the Ten Mile and the upper Housatonic together, Mr. Freeman estimated that 750 m.g.d. could be delivered to the city by gravity at an elevation 300 feet above sea-level. There were no adverse water supply interests in Connecticut and only a moderate amount of water power would suffer by the diversion. Barred from the Ten Mile-Housatonic by unfavorable legal opinion, especially by the fear that adverse legal action by Connecticut might cause fatal delays, the city, after six more years of deliberation, proceeded with the construction of the Catskill

system which is now approaching completion, going for its water two and one-half times as far as to the Ten Mile-Housatonic.

In 1903 to 1905 the water supply situation in Richmond Borough of New York City was acute, the supply being inadequate in quantity and very poor in quality. The island borough of Richmond while politically a part of New York City and State is geographically a part of New Jersey, and its shores are washed by the waters of two of New Jersey's largest rivers, the Passaic and the Raritan. A New Jersey corporation wished to furnish, and New York wished to buy, at least a temporary supply of 3 to 10 m.g.d. to tide over the interval pending completion of the Catskill works. The proposed diversion was about 0.1 to 0.4 per cent of the quantity which Mr. Hazen has since shown to be available for this part of New Jersey, and from a watershed of which 141 square miles or 18 per cent was in New York. In 1905 New Jersey enacted legislation prohibiting the transportation of any of the fresh surface waters of the state "into any other State, for use therein." In consequence Richmond borough endured for twelve years longer an inadequate and inferior supply and now gets its water from the Catskill mountains 120 miles or five times as far away.

New York State now again finds it necessary to seek large new supplies for its metropolitan area. While this state has been particularly fortunate in being able to develop its present large supplies on watersheds wholly within its own boundaries, it cannot continue to do so indefinitely. On the north, east, south and west its waters drain into adjoining states or into international streams. With thousands of square miles of the watersheds of interstate streams within its own boundaries it will find it difficult to supply its own cities unless some effective interstate coöperation can be had.

While the preceding examples are all projects of unusual magnitude, the problems under discussion arise also in the development of small municipal and private water supply works. These smaller projects, however, frequently involve such minor encroachments upon the riparian rights of citizens of the neighbor state as to escape the notice of jealous state officials and legislatures, and to admit of settlement by ordinary judicial process or by agreement, without raising troublesome questions touching the dignity, sovereignty and supposed vital interests of a state.

The preceding examples show some of the difficulties of the present situation, fundamentally the lack of any system of allocation as

between states. Lacking allocation and such interstate or superstate authority and control as will make allocation both possible and effective, the water supply engineer and his client, contemplating a diversion even within their own state, from an interstate watershed, are left in a fog of uncertainty and doubt. If proposing a diversion in an upper state, what costs and delays will have to be met before the proposed diversion can become effective, and how much if anything will they ultimately be permitted to divert? If proposing a development in a lower state can they rely upon the undiminished flow from the upper state, or will they at some time find themselves, even temporarily, deprived of water; and what, if any, coöperation in enforcing sanitary protection will they have in the upper state? If one of the contiguous states proposes to divert from the boundary stream, there is added to all of the above the further question: What protection will they have in their proprietorship in waters released into the channel above the point of diversion from storage built by and in the diverting state? And should economic development and effective utilization require the acquisition of property, the flooding of lands or the construction of works in another state, there are added to all the other difficulties the lack of power of condemnation, the possibility of excessive and discriminatory taxation, and existing or possible prohibitory legislation in the other state.

Three general lines of action, other than the negative one of shunning interstate waters at all costs, as exemplified in the recent history of New York, are now available:

1. To take what is wanted regardless of the interests of lower states and hope to get away with it.

2. To take what is deemed reasonable and just, to endeavor to reach amicable settlement with all lower interests, and hope the judgment and action will be sustained by the courts.

3. To endeavor to secure an allocation in advance.

The first two place ultimate reliance upon possession and upon a successful defense in the courts, to confirm the appropriators in the enjoyment of that which they have taken. The first has had its most perfect development in irrigation work in the West, and is the only line of action which, so far as writer knows, has lead to a definite allocation by the court of last resort, of the waters of an interstate stream (Wyoming v. Colorado, 259 U. S. 496; 260 U. S. 1). The second has succeeded in two of the Massachusetts cases cited,

and is hopeful where the diversion is small or limited to flood flows, where there is no conflicting water supply demand in the other state, where injuries are susceptible of pecuniary compensation, where the diverting authority is prepared to deal generously with lower riparian owners, and where breadth of view and a desire for harmony, rather than prejudice, suspicion and jealousy and the exigencies of local politics, determine the attitude of officials of the interested states. Both lines of action are, however, under the shadow of probable or possible costly litigation and vexatious delays, of an eventual judicial limitation of the diversion, and possibly even a sustained injunction which would prevent utilization of the works.

In following either of the first two methods the engineer has no body of federal or interstate law to guide him. Under the Federal Constitution the power of the United States over the waters of an interstate stream is limited to the preservation and improvement of navigation. The decisions of the United States Supreme Court are, however, gradually building up a body of what is in effect interstate law. Unfortunately the decisions pertinent to our problem are few, and not in all respects consistent. The cases dealing directly with the diversion of interstate waters are as follows, in the order of date:

*New York v. Pine (185 U. S. 93), 1902*

Suit to enjoin a diversion for municipal water supply, the works for which were far advanced in construction Action of a lower court granting an injunction reversed, not on the merits as a controversy over interstate waters, but on the grounds of delay on the part of the plaintiff and other considerations.

*Missouri v. Illinois (180 U. S. 208; 200 U. S. 496), 1906*

Suit to enjoin pollution by discharge of sewage of a community outside the watershed, the Sanitary District of Chicago. Dismissed, without prejudice, on the grounds, apparently, of failure to prove any injury, and especially, failure to prove that such pollution as there might be was not due at least in part, to sewage discharged within the plaintiff state.

*Kansas v. Colorado (185 U. S. 125; 206 U. S. 46), 1907*

Suit to enjoin a diversion long practiced by and under the authority of Colorado, as well as proposed additional diversions. Dismissed, without prejudice, on the grounds that, while the injury to Kansas was real, "regarding the interests of both States and the right of each to receive benefit through irrigation and in any other manner from the waters of this stream, we are not

satisfied that Kansas has made out a case entitling it to a decree. At the same time it is obvious that if the depletion of the waters of the river by Colorado continues to increase there will come a time when Kansas may justly say that there is no longer an equitable division of benefits and may rightfully call for relief against the action of Colorado, its corporations and citizens in appropriating the waters of the Arkansas for irrigation purposes."

*Hudson County Water Co. v. McCarter (209 U. S. 349), 1908*

To review decrees of the lower (New Jersey) courts enjoining diversion of water from Passaic river for sale to the City of New York in violation of a New Jersey statute prohibiting the transportation of the fresh surface waters of the state "into any other State, for use therein." The constitutity of theional New Jersey law was upheld.

*Wyoming v. Colorado (259 U. S. 496; 260 U. S. 1), 1922*

Suit to prevent a proposed diversion under the authority of Colorado. Decree enjoined the defendants from diverting more than 15,500 acre-feet per year by means of the Laramie-Poudre project, determined the "fairly constant and dependable flow" realizable "by means of practicable storage and conservation," and apportioned the whole of this reasonable flow between the two states, on the basis of priority of appropriation. This was a question between states, dependent upon irrigation, and both of which recognized the doctrine of prior appropriation, not the common law of riparian rights which prevails generally in the East.

Reasonable limits of space preclude a fuller discussion of these and of other pertinent decisions of the United States Supreme Court and of other courts. At least those so briefly cited will well repay the study of any engineer contemplating a water supply diversion from the watershed of an interstate stream.

The third line of action, that of endeavoring to secure an allocation in advance, is the only one which can place a water supply project involving an interstate stream on a thoroughly sound foundation in advance of construction and use, as it is also the one which best promises to solve the problems of acquisition of property, flowage of lands and operation of works in another state. Within their own boundaries and as between their own citizens many states have long since recognized this principle by the creation of water supply or conservation commissions, empowered and directed to make such allocations.

Allocation as between states or the citizens or corporate creatures of different states implies some authority superior to any single state. Such authority might reside in an interstate treaty respecting a particular case, in a continuing interstate commission deriving its authority from a treaty, or in the federal government. A treaty,

negotiated by commissioners appointed by the interested states and ratified by the legislatures of those states and by the Congress, is binding, but tends to be inflexible, although provisions for future modifications and review can be incorporated in the compact. In efforts toward this solution the states of the semi-arid West have lead, seven examples of treaties now in various stages of negotiation, for the allocation of water primarily for irrigation, having been recently noted in the engineering press;[5] and the Colorado River Compact, the pioneer and the most ambitious of these treaties has since been ratified by six of the seven interested states. In the East a joint commission to study the most effective utilization of the waters of the Delaware has been authorized by the legislatures of New York, New Jersey and Pennsylvania, and commissioners have been appointed by these states. It is suggestive that one state has appointed its Commissioner of Health, its Secretary of Forests and Waters and its Deputy Attorney General.

A continuing interstate commission offers many advantages. It could exercise the necessary control to insure that the terms of each allocation were fulfilled, could provide the flexibility requisite to meet changing needs, should be able to solve problems of interstate sanitary control as they arise, would, by the fact of its continuity, maintain a constant touch and familiarity with the interstate water problems of its field, and, not least important, would avoid the very serious delays incident to creating new machinery whenever the need for a new allocation arose.

The principles which should govern the allocation of waters would appear to be these: The public ownership of flowing waters whether above or under ground; administration of these waters on a regional, if not a national, scale, such regions transcending not only state lines but divides as well; beneficial use as "the measure, the limit, and the basis of the right;"[6] an established order of preference as to class of use, which order, except for domestic and municipal water supply, will vary with changing conditions of time and place; the better right within each preference class of use determined by priority in time of perfected use; limitation of allocations with due regard to economy and efficiency of use; compensation for reduction or cancellation of an allocation or of a prior grant or prescriptive right to be based on reduction in amount of water in actual and

[5] Engineering News-Record, September 27, 1923, p. 505.

[6] Some Principles Relating to the Administration of Streams, Clarence T. Johnston, Trans. Am. Soc. C. E., 1915, p. 630, and discussions.

habitual efficient use, interpreting "efficient" in the light of the state of the art concerned at the time of deprivation, with no compensation for deprivation of water wasted by non-use or inefficient use; abandonment to the public of rights of use not promptly utilized in the manner specified in the grant, except that, subject to approval of the administrative authority, rights of sale of a temporary surplus, to help carry charges on costly works by which it has been made available, should be secured; and maximum economy of development for all uses, on the regional scale. A discussion, before the American Society of Civil Engineers, of the administration of streams,[6] by Clarence T. Johnston and others, is highly illuminating and suggestive, and develops many of the principles here outlined. As to order of preference in use, domestic and municipal water supply will doubtless always be recognized as the highest use. The relative order of other classes of use, disposal of sewage and industrial wastes, irrigation, navigation, water power, supplies of industrial and process water, fisheries, and aesthetic and recreational use, must vary with progress in the arts concerned and with predominant local needs, that is with time and place.

In any current project of large magnitude it is the writer's feeling that an interstate commission to examine the situation, formulate a policy and recommend an allocation, such allocation to be embodied in a treaty between the states, offers the line of least resistance and greatest present promise. This is, however, merely an expedient and does not reach the heart of the problem. The very serious loss of time which this procedure involves, and the chance of an unsympathetic response by some of the states invited to participate might be overcome, with respect to future questions arising among the same states, by some continuing interstate commission empowered to make binding allocations; and only by some form of continuing administrative authority can application of the principles outlined be even approximately realized, either pending or after the revision of our water laws. The practical working out of the problems of allocation by this method is so new that much effort and study will be required to establish the principles and to evolve the best mechanism and procedure. It is hoped that this paper may promote discussion which will crystallize the problem and perfect this or some better method of attack.

In closing, the writer wishes to acknowledge his indebtedness, for many valuable criticisms and suggestions, to Mr. J. Waldo Smith at whose instance this paper was written.

# THE CLEANING OF CAST IRON WATER PIPE LINES

By Charles Haydock[1]

Cast iron pipe comprises the greatest length of all pipe lines laid to convey water. It is unquestionably true that, under normal conditions, a cast iron pipe line is relatively permanent, but this does not cover the entire situation, as it neglects the function of the pipe line, which is to convey water. If the capacity of the pipe line is reduced, the value of the pipe line is impaired to an equal extent, even though there has been practically no loss of metal from the pipe line coincident with the reduction in capacity.

Many of the water supplies of Eastern United States are of a desirable type, that is, they are soft and low in total solids and alkalinity. Unfortunately these desirable waters may also be classified as "active waters," in that they actively corrode pipe lines. For this reason the loss in capacity of pipe lines due to tuberculation is, in general, a more serious item in Eastern United States than in other sections of the country. Wherever the coating is imperfect or punctured, even if only to the extent of a pin hole, a tubercle forms which continues to grow indefinitely. A comparatively small amount of tuberculation is sufficient to cause a serious loss in capacity, due, no doubt, to the eddy currents set up by the roughened interior. The reduction in area by tuberculation is not usually material, unless the line is quite old or the water very active.

The expansion of our water works systems has been so rapid in recent years that the average age of the pipe lines is not yet very great. As this increases, the seriousness of loss of capacity due to tuberculation will increase.

Loss in capacity is not always due to corrosion or tuberculation, but this is by far the commonest cause throughout the soft water area of eastern United States. In order to prevent such losses, two lines of action are open, treatment of the water and of the pipe.

Concerning the quality of the water, it has been stated that these active waters are of a most desirable type, and in general, it is

[1] Engineer, Water Companies, Philadelphia, Pa.

difficult to secure public approval of any method of treatment which would reduce the activity of the water at the expense of its softness. In many cases this is probably poor economy, as the active waters attack plumbing and service lines, etc., with such vigor as to constitute a greater annual expense per capita than would be required to reduce the activity, while the slight increase in hardness which might occur, as a result of reducing the activity, would scarcely be noticeable in many cases.

Very gratifying results have been secured by improving the quality of metals and in using alloy metals for many purposes in various industries in an effort to reduce corrosion. Application of such principles to the cast iron pipe industry might increase the cost of pipe over the cost of that now used, but if the carrying capacity of the pipe line could be mintained, it is believed that private water companies and progressive municipalities would be willing to pay the additional cost for the greater value secured. The only recent development of importance in the pipe industry is in the use of the centrifugal or de Lavaud process of casting pipe, which has been described before the Association at the Philadelphia Convention in 1922. Pipe manufactured by this process has not yet been in use long enough to demonstrate whether its carrying capacity is any more permanent than sand-cast pipe, but considering the methods of casting and the fact that a better grade iron is used, it should produce a pipe more resistant to tuberculation and corrosion.

Another method which suggests itself is improving the character of the coating. The writer does not believe that this holds as much promise as improvement in the pipe, for any impairment of the coating, whether due to abrasion, such as frequently occurs in shipping and handling, air bubbles or any other cause, opens an avenue of attack upon the metal. Recently a considerable tonnage of cast iron pipe has been coated with high grade asphaltic enamels, such as have been used very successfully on ship bottoms, and in similar locations exposed to unusually difficult conditions. This coating is much thicker and adds materially to the cost. The increased cost can no doubt be reduced if there is sufficient demand for this greater protection to warrant installation of the necessary facilities for handling. It has been suggested that it might be possible to develop a cheap process of porcelain lining for cast iron pipe which could be used to carry very active waters, but so far as the writer knows, no serious consideration has been given to this,

as it will readily be appreciated that it will require a very tough porcelain to be suitable for such purposes, while the difficulty of tapping and cutting mains would be greatly increased.

Loss in capacity may also be due to air binding at summits, sediment at low points, precipitation from softened water, dropped gates of valves and foreign matter in the line. Many curious things have been removed from pipe lines during cleaning operations, including picks, shovels, axes, lumber, caulking tools, dinner buckets, overalls, stones, etc.

The purpose of this paper is to discuss only the losses due to corrosion and tuberculation, and results obtained by cleaning such lines. The benefits of cleaning are usually greatest where fuel costs are highest or capacity limited, or both, which generally occurs on long mains between sources of supply and centers of distribution.

Pipe cleaning is not a new process and has probably been practiced as long as pipes have been used to convey liquids. Probably the first large scale cleaning operations were in cleaning oil lines, some of which lose capacity quite rapidly, due to the deposition of paraffin. This deposit is quite soft and can readily be removed by passing a cleaner, similar to a boiler tube cleaner, through the pipe line, using the oil pressure as the driving force. Water mains may be cleaned in the same manner, but it is a much more difficult process, as the deposit is harder, the pipe lines generally larger, the length of time for which the line can be removed from service for the cleaning operation is usually less and the pressures are in general lower. If the normal pressure is insufficient to force the cleaner through the line, it can be pulled through by a cable and winch, but this is usually impractical in long lines of large diameter. It is also possible to install a temporary pump to raise the pressure to force the cleaner through the line. If a high pressure system is available nearby, a temporary connection may sometimes be arranged and the required pressure secured in that way.

Cleaning is not a remedy in all cases of reduced capacity of pipe lines, but it is of decided advantage in many instances, and it is here desired to call attention to certain definite cases in which very gratifying results have been obtained. The writer's experience indicates that the effects of cleaning are not permanent and careful consideration of the facts will indicate that this is logical. The length of time during which the benefits persist varies, depending chiefly on the same factors that influenced the original loss in capac-

ity, namely, the character of the metal and the nature and condition of the coating. A cleaning operation, vigorous enough to dislodge tubercles, will also injure the coating to some extent, and this opens an avenue for more rapid corrosion after cleaning than before, as no method has yet been devised to recoat the interior of a pipe line underground. This, however, is not a valid objection to pipe cleaning, for, where cleaning is needed, the cost of same is usually reasonable. In most cases, the company could well afford to clean the pipe line at intervals of the life of the benefits of the cleaning rather than to lay new pipe lines or build booster pumping stations to increase capacity or pressure, or both.

The attention of the Association has previously been called to the conditions at Charleston, S. C., where the effects of pipe cleaning have disappeared within a few months, due to the great activity of the water. Fortunately, this is an unusual condition. The cost of pipe cleaning is certainly not warranted in such cases, and the solution adopted of coating the interior of the pipe with cement seems to be more practical.

If the capacity of a long line appears to be decreasing or the pumping head increasing, the actual carrying capacity should be determined. If this is materially less than the theoretical capacity, a careful investigation should be made to determine the cause. A survey and determination of the hydraulic grade line is usually worth the cost, and will disclose any unusual conditions. If it is possible to shut down the line, static pressure or a siphon test will show how tight it is and a recording meter will complete the record. If there is no meter available, a pitot test can be made at a reasonable cost. The presence of consumers' taps and branch connections increases the difficulty of cleaning a line. After a pipe line has been cleaned, it is sometimes necessary to pump out the consumers' taps attached to same by means of a force pump for the reason that the particles dislodged in the interior of a pipe line may be forced into the corporation cocks. Branch connections and valves are sources of possible difficulty in cleaning a line by reason of the possibility of the cleaner sticking at such points. Having all this information available, it is usually possible to forecast the probable benefits of cleaning.

The writer's first experience in pipe cleaning was gained when two parallel lines from a reservoir to a railroad yard were cleaned. This line was particularly difficult as it contains many bends and is of

various sizes, the exact location of the reducers being then unknown. Some of this pipe was laid in the fifties and sections removed indicated that it was uncoated pipe, cast on the side in 9 foot lengths. Before this line was cleaned, it carried a little more than half the theoretical capacity, while, after cleaning, this was increased to nearly 90 per cent. The other line from the same reservoir was twenty or thirty years old and is the usual 12 foot coated pipe. Its capacity was increased from two-thirds to more than 90 per cent of that of new pipe. Such results are most encouraging. The unfortunate feature is that the results were not permanent and, about five years later, the capacity had decreased to approximately what it had been before cleaning. As the uncoated pipe had no protection at all, it is natural that it should have corroded rapidly following cleaning. This is an unusual condition, which, fortunately, is not often encountered.

The capacity of a pipe line approximately 3 miles long, half of which was 10 inch, about thirty years old, the balance 12 inch, twenty years old, was known to be inadequate and on investigation it was determined that this was due not only to tuberculation 1 inch thick in the 10 inch portion, causing a material reduction in area, but also to serious leakage in two creek crossings which did not show on the ground. In cleaning the 10 inch line, a joint missed at the first pouring was encountered. The lead in the pipe weighed about 50 pounds and measured 4 feet along the bottom of the pipe. The cleaner picked this up and rolled a portion of it into a ball until the weight was so great as to stop the cleaner under the low water pressure available. As a result of this, it was necessary to cut the line to remove the cleaner. Due to the cleaning and reduction in leakage, the capacity was more than doubled, so that it was nearly equal to that of a new line. All of this increase in capacity can be credited to the job, as the leakage would not have been found unless cleaning had been done. A further result of this cleaning was that it was possible to discontinue the operation of a pumping station which was originally installed as an emergency or stand-by unit, but due to the decreased capacity of the line, it was necessary to operate the station continuously for some time.

Another line cleaned was approximately 5 miles long. The available head was so low that there was not sufficient pressure to force the cleaner through the line. Rather than pull it through by means of a winch, a temporary boiler and pump were set up and water

pumped into the line at a pressure sufficient to move the cleaner. In this way, the line was successfully cleaned and the capacity was greatly increased. As in the last case, this increase in capacity was sufficient to enable the discontinuance of a pumping station, which had originally been installed as an emergency unit, but had become practically a permanent installation by reason of the decreased capacity of the gravity line. The blow-off valves and automatic air vents on this pipe line had not been properly maintained, and were therefore not functioning. It was found that there was a considerable accumulation of sediment at the low points and that the capacity of the line was further reduced by air binding at the summits. Here again, while all of the increase in capacity was not due to the passage of the cleaner through the line, it is believed that all of the benefits are properly to be credited to the cleaning operation, for, if this had not been undertaken, the other difficulties would not have been located and it would have been necessary to continue the operation of the pumping station.

At another point, the discharge from a pumping station to a reservoir, consisting of parallel lines of 12 inch and 16 inch pipe, approximately fifteen years old, was investigated, and it was decided to clean both lines, starting with the 12 inch. After this was done, it was found that the 12 inch was carrying a much larger percentage of the flow and that the capacity had been increased approximately 30 per cent. These figures indicated that the cost of cleaning the 16 inch pipe line was unwarranted, as the reduction in pumping head which could have been accomplished by pumping through a clean line would not have decreased the fuel bill sufficiently to warrant the cost. The performance of this system is being observed and the 16 inch line will be cleaned as soon as capacity becomes a controlling feature or the possibilities of fuel saving become attractive. This line contained comparatively few tubercles, some of which were quite large, reaching a diameter of 1 inch and a height of $\frac{5}{8}$ inch. At one point in the line the cleaner was stopped by a small stone wedging between the cleaner and the seat ring. Upon removing the bonnet, it was possible to pry the cleaner loose and the stone was removed. At another point a "missed" joint was encountered, the lead having spread out to a length of approximately 4 feet and contained almost sufficient lead to run two joints. The water carried in this line is filtered. The total solids are always quite low and the alkalinity of the raw water seldom exceeds 12 to 15 parts per million,

while in the spring it becomes very low. This water is of the type first mentioned in that, while it is of a very desirable quality as to its total solid content, it is also very active and attacks the pipe line quite rapidly.

Another job consisted of cleaning 4 miles of 12 inch line, approximately twenty years old, the frictional loss through which before cleaning was nearly three times that of new pipe, and after cleaning, approximately the same as that of new line. The capacity was increased by approximately 35 per cent and the delivery pressure by 20 pounds under normal operating conditions. It would have been possible to obtain a greater increase in capacity by delivering at the same pressure, but the increase in pressure was a very desirable feature under the operating conditions. In cleaning this line, an axe complete with handle was recovered, also an iron wedge from a gate valve and a number of stones of various sizes, several of which were quite large.

A 10½ mile section of 16 inch pipe line in the same system was also cleaned. As a result of this cleaning it was possible practically to discontinue the operation of a booster pumping station for the delivery without pumping after cleaning was greater than the delivery with pumping before cleaning. The gravity delivery of this line was increased 60 per cent. By reason of the increased flow, the percentage of increase when boosting after cleaning was only 30 per cent. The testing done in connection with this work disclosed the existence of two serious leaks along the pipe line, of which there was no indication on the surface of the ground. The tests also disclosed the existence of a valve of which there was no previous record. This valve was nearly closed, and under maximum delivery caused a material loss of head through the pipe line. The increase in capacity was therefore not due entirely to cleaning of the line, but was also due to the elimination of the leaks and the excessive loss of head.

The capacity of a 4 inch pipe line a mile long supplying a small railroad water station was found to be so reduced that the laying of a new line was contemplated, but by cleaning a capital expenditure was avoided. The loss of head available in this line was so small that it was necessary to pull the cleaner through, at which time it was found that a summit was practically level with the intake, and the low points had material quantities of sediment. The cleaning was done in the winter time when the ground was covered with a foot of snow. The location of this pipe line was not known definitely,

and it was necessary to prospect for same. As a result of this, the cost of the work was at least double what it should have been. The increase of 40 per cent in capacity is sufficient to obviate the necessity of renewing the line for a considerable period in the future.

During the past summer 22 miles of 12 inch trunk line have been cleaned. The cleaned line consisted of three sections, the longest of which is more than 13 miles. The increase in capacity due to cleaning this portion was approximately 35 per cent. The unit length cleaned was governed by the location of a number of 90 degree bends, through which it was not considered advisable to attempt to pass the cleaner. These units ranged in length from ½ to about 4 miles.

The second section of this line, more than 3 miles long, was cleaned with similar gratifying results. In this section the pressure was low, and considerable difficulty was experienced in cleaning on that account. Under certain conditions there was practically no flow previous to cleaning. After cleaning, under similar conditions, the flow was approximately 350,000 gallons per day. The percentage increase in such cases is hardly a fair criterion, but this improved condition is of the greatest value in the operation of the line.

Cleaning the third section of this line, which is more than 6 miles long, and carries ample pressure for cleaning, resulted in an increase in capacity of approximately 46 per cent. The cleaner successfully passed through no less than five 45 degree bends in this section, but did not pass through a sleeve which had been used to make a 15 degree bend. The ends of the pipe had not been properly brought together at this point and a large stone dropped into the space. The cleaner wedged against this and it was necessary to cut the line to remove it.

This pipe line is approximately sixteen years old and carries a high quality water which is quite active, and the tuberculation was sufficient to reduce the diameter of the line in many places. The tuberculation was not evenly distributed along the line as some sections were comparatively free while others, as above noted, showed a reduced diameter. Cleaning this pipe line disclosed the usual number of foreign objects, including many stones, a 6 foot piece of 2 by 4 inch lumber, a complete shovel and a shovel handle. No doubt the shovel itself will be recovered at some later date, probably under a valve or else by obstructing the cleaner. It seems impossible to keep such foreign objects out of a pipe line and, while it is most unfortunate that this is true, it is hardly likely that in the

average case the capacity of a line is materially reduced unless they are collected at a critical point, such as a valve or bend.

These 22 miles of pipe line which were cleaned comprise the critical sections in a 48 mile length of 12 inch line. The benefits derived consist not only in the increased capacity, but an important item was in reducing outside purchases of water. There are comparatively few points along this line where water can be purchased. None of these available waters are equal in quality to the water carried by the line and they are also more corrosive and expensive.

Approximately 3 miles of 10 inch pipe line has been cleaned very recently. The water supply at this point is obtained from a large river which is always quite hard and frequently acid. In order to correct these conditions, the water is treated constantly without sufficient sedimentation capacity. As a result of this, the treated water is not properly settled and precipitation occurs in the pipe line. The water is relatively inactive and there were comparatively few tubercles, but the sediment from the treating plant had formed a coating approximately $\frac{3}{4}$ inch thick throughout the line. This coating was readily removed and was discharged from the blow-offs like molasses. The increase in capacity due to cleaning was 65 per cent, while, under operating conditions, 20 per cent more water is delivered at double the former pressure.

Summarizing the situation, it is apparent from the examples cited that in many cases, pipe cleaning, especially of long transmission mains, will produce very substantial benefits where there is a deficiency in capacity or pressure. All water companies do not have the problem of long transmission mains, but those which do, in many cases, would find it to their advantage to investigate same, as actual conditions may be determined only by observations.

In view of the present high cost of labor and materials, pipe cleaning is particularly attractive as it permits restoring the capacity of a pipe line at a reasonable operating cost and avoids capital expenditures.

# ELECTRIC PUMPAGE AT KANSAS CITY, MISSOURI[1]

By Albert L. Maillard[2]

Recently a decision was made as to whether steam turbine or electric motor drive should be adopted in the proposed new high lift pumping station for the additional water supply of Kansas City, Missouri. The electric motor was selected. This action seems, on the surface, to be contrary to the accepted best practice followed for years and in vogue today, under similar conditions. While it is true that Kansas City, Missouri, has a direct pumpage system and is neither adjacent to nor fed by any hydro-electric power system, yet there are local conditions which make electric pumpage indeed very desirable.

Before stating the factors which entered into the final decision it might be well to discuss the nature of the investigations and studies that were made of both the steam and electric stations as to their design, cost and reliability of service.

The scope of the additional water supply works for Kansas City, Missouri, comprises an intake and low lift pumping station, located on the river near North Kansas City, Missouri, a purification works and secondary lift station some two thousand feet away from the river bank in North Kansas City, a main pressure tunnel and two branch pressure tunnels connecting the secondary lift station with the existing high lift station known as Turkey Creek station and the proposed new high lift station in the East Bottoms, Kansas City, Missouri, an equalizing reservoir at the East Bottoms station, and the necessary distributing mains from the new high lift station.

The low and secondary lift pumping stations will be equipped with six 40 m.g.d. pumps each. Four of these pumps will carry the maximum load, while two will be held in reserve. The head at both

[1] Prepared under the direction of the Standardization Council and furnished through Committee No. 3, on Pumping Station Betterments, L. A. Day, Chairman.

[2] Electrical Engineer, Fuller and McClintock, Consulting Engineers, Kansas City, Mo.

of these stations varies widely; that at the low lift chiefly due to changes in river stages while that at the secondary lift due to friction in the tunnels. At each station the range in head is from about 18 to 50 feet. A maximum of about 500 horse power will be necessary to drive each of these pumps. A steam turbine of that capacity is comparatively small and consequently not very efficient. Then the boiler plants required for these two pumping stations would be small. Since they would be independent plants it would be necessary to carry spares in each plant. Besides, it would be very expensive to build a boiler plant at the low lift station, due to the fact that the pump room floor in this station has to be located some 34 feet below the present grade, making the structure a rather expensive one. Increasing its area would add considerably to its cost. At the secondary lift station there are, in addition to six pumps similar to those at the low lift station, several small pumps in connection with the purification works which pumps would be more cheaply and better equipped with electric motor than with steam turbine drive. For the foregoing reasons, it is better to drive all pumps at the low and secondary lift stations electrically.

The high lift station, based on steam turbine drive comprised four 35 m.g.d. units and four 2250 k.w. turbo-alternators for generating the current required at the low and secondary lift stations. The pumping units provided one spare, while the generator units provided two spares. Thus, by concentrating all steam generation at one point the best possible efficiencies are obtainable. The turbines driving the pumps and those driving the generators were to be exact duplicates of each other and of the highest efficiency obtainable. The 35 m.g.d. capacity was selected because it necessitated a turbine of about 3000 horse power at which size very good efficiencies are obtainable. Yet this capacity gave enough flexibility to suit the expected water consumption.

Compared with this combination of steam high lift and power house and electric low and secondary lift stations was the proposition of driving the pumps at all stations electrically with power purchased from one of the public utilities.

The high lift station, when electrically equipped, contemplated six 24 m.g.d. pumps instead of four 35 m.g.d. as in the case of steam turbine drive, due to the fact that greater flexibility could be obtained without sacrificing any efficiency in the electric motor.

Since the low and secondary lift stations would remain unchanged regardless of whether steam or electric drive were adopted at the high lift station, the comparison of costs of the two schemes resolved itself into that of the total operating and fixed charges of a steam pumping station and electric generating plant as against those of an electric pumping station operated with purchased power.

Other considerations which necessarily entered the investigations were those of reliability of service and flexibility of operation.

In regard to the latter it might be said that since centrifugal pumps are under consideration the range of flexibility per unit is rather limited. It is true, however, that the steam turbine with its ability to increase or decrease its speed above or below a certain normal has an advantage over the constant speed motor as well as over the variable speed motor, although not to such a marked degree in the case of the latter.

This advantage can be offset considerably by reducing the size of the electric motor driven units relative to that of the turbine driven pump. To attain this result six 24 m.g.d. pumps were substituted for four 35 m.g.d. units as were considered with steam operation. The motors for the 24 m.g.d. units at 380 feet head are approximately 2000 horse power. Their efficiencies are almost identically equal to those of 3000 horse power rating. In consequence, no loss of efficiency has been suffered while greater flexibility has been gained. It might be well to emphasize this fact, namely, that the existing high lift station known as Turkey Creek Pumping Station is steam operated and is equipped with two turbo-centrifugals, one a 20 m.g.d. and the other a 30 m.g.d., as well as three 20 m.g.d. triple expansion reciprocating engine driven units. These last mentioned carry partial loads efficiently and can be depended upon to take care of the fluctuations in load which range between even multiples of the centrifugal units.

Other considerations which come under the head of flexibility of operation are those of labor and time entailed in starting and stopping turbines with the attendant boiler room adjustments (such as operating of boilers at ratings which will reduce to a minimum banked fires without imposing too severe load conditions on the boilers and yet operate them normally at an economical rating), compared with the ease of starting and stopping motors.

Regarding reliability of service there is no doubt that the steam plant is the more dependable. The question is by how wide a margin.

Kansas City, Missouri, is fortunate in that it is served by one of the most modern and efficient steam power plants in the world. The "Northeast" station of the Kansas City Power and Light Company, located within a mile of the site of the new high lift pumping station in the East Bottoms, serving this pumping station, through underground feeders, directly from its busbars to the busbars of the pumping station, without the intervention of transformers, has in its favor ideal conditions for rendering this service. The contract between the Company and the City provides that the latter will have first call on the entire generating capacity of the Company's power stations. The contract provides, also, for very liberal feeder capacity, connecting the stations by two separate and independent routes. It further provides that the feeder capacity be such that the cables in any one duct line shall be able to carry the entire load of the pumping station in case the other duct line be taken out of service for any period of time. In addition, no other consumer can be fed from these cables. With the taking of these and other precautions, too detailed to be included within the scope of this paper, it is felt that the service will be as reliable as it is possible to obtain with the best equipment and methods in use today. It may not be too optimistic to feel that the service will so closely approach in reliability that of a steam station that there will be little argument for choosing the latter other than that prompted by sentiment.

The comparison of the relative costs of constructing and operating the two types of stations was carefully investigated. Design studies were made of both types of stations. Detailed estimates of costs of construction based on current prices obtained from the various manufacturers were made. From the capital investment thus obtained, fixed charges were determined. In the case of the steam station operating conditions were based on the best modern practice used in medium sized steam central stations. The electric station also was patterned on best modern practice. Costs were grouped under the following headings: Fuel, electric power, labor, lubricants, supplies, maintenance and repairs, interest, depreciation, and transmission line lease.

Load variations with corresponding changes in operating conditions as well as in investment and consequent fixed charges were made every five years. The periods started with the year 1928 and followed on with 1933, 1938, 1943 and 1948. This means of comparing costs showed which type of station would really be best in the end for the City to adopt.

Before the cost of electric power and the transmission line lease could be calculated it was necessary for the City to secure bids for power from the local companies supplying power. In addition to being in competition with each other the companies had to compete with steam operation of the pumping station. These factors resulted in obtaining for the City a very low rate. In consequence the City has entered into a contract with the successful bidder, namely, the Kansas City Power and Light Company, to supply current at the City's pumping stations in the form of three phase, sixty cycles at thirteen thousand two hundred volts and at the following rates:

Demand charge—$1.56¼ per month per kilowatt, plus $3000 per month to cover charges on transmission lines

Energy charge—$0.007 per kilowatt hour until the demand at the high lift station exceeds 2800 kilowatts.
$0.00675 per kilowatt hour until the demand at the high lift station exceeds 4250 kilowatts.
$0.0065 per kilowatt hour until the demand at the high lift station exceeds 5600 kilowatts.
$0.00625 thereafter

These energy rates are subject to a fuel rider which in substance states that, should the cost of fuel to the Company vary from a price of four dollars a ton, the City shall pay an addition on or receive a deduction from the rates depending on whether the price of fuel increases or decreases.

The contract contains also a power factor clause. The rates stated are based on 0.8 power factor. Should the pumping station load be at a power factor of more than 0.8 then the demand charge is reduced in the ratio of the actual power factor to 0.8 power factor. For example, should the City maintain a power factor of unity (1.0) the billing demand will be eight tenths of the demand charge, namely, 0.8 × $1.56¼ or $1.25 per month per kilowatt.

To obtain the benefits that accrue from this power factor clause synchronous motors will be installed at the high lift station for the main purpose of obtaining a high power factor.

These rates were applied to the loads that are expected at the pumping stations during the years starting with 1928 and ending with 1948 and the resultant costs tabulated under the headings as herein stated. When the electric and steam stations were compared on a basis of total annual costs, the former showed a saving over the latter of about 3 per cent at the outset or initial five year

period. In the later periods, however, the saving in favor of electric drive was overcome and the steam drive showed a saving which increased until it was about ten per cent in the final five year period. It must be realized, however, that these percentages are well within the limits of accuracy of judgment which may now be expressed as to efficiencies and economies to be actually realized during a period of twenty or twenty-five years of future operations.

So far there is a slight advantage in favor of steam. A local factor of unusual significance, however, has practically controlled the situation and has turned the scales in favor of electricity. The estimated cost of the additional water supply works, according to the report of Fuller and Maitland, engineers for these works, is, in round numbers, twenty million dollars. Only eleven million dollars have been voted by the City and a program of new works has to be worked out to fit this amount of money. The saving in investment if electric pumpage were adopted would amount to fully two million dollars for the complete new works needed by the City during the next twenty-five years, and upwards of one and a half million dollars could be saved in the first installation of works, of which about eight hundred thousand dollars would be due to electric high lift pumping. This large saving in investment was the controlling factor in deciding in favor of electric pumping at the high lift station.

# SOME EXPERIENCES WITH A STEAM TURBINE DRIVEN CENTRIFUGAL PUMP IN THE ST. LOUIS WATER DEPARTMENT[1]

By Leonard A. Day[2]

Steam turbine driven centrifugal pumps have been used for pumping raw water at the low service station of the St. Louis Water Department for some time; two units of this type, each having a nominal capacity of 40 m.g.d., having been installed in 1912. These units are driven by an impulse steam turbine, very simple in design, consisting of only one high speed turbine wheel. They have been very satisfactory from the stand-point of reliability, the only difficulty being due to cutting of the turbine buckets on the wheel during the time that saturated steam was in use at the plant. With the introduction of superheated steam, erosion has practically disappeared. If the wheel becomes worn, it can easily be removed and rebladed at the plant.

A new turbine driven centrifugal pump having a capacity of 110 m.g.d. against a head of 65 feet was placed in service in March, 1919. This unit is of the conventional geared type, but the turbine, being much larger than the original units, is provided with 13 velocity stages for economy. The operation of this machine has not been as free from difficulties as that of the smaller and more simple single-stage turbines. It was noticed after this machine had been in service for practically two years that a considerable dropping off in capacity took place. It was no longer possible to operate the unit at its full capacity.

At first it was believed that the water end was causing the trouble. Consequently a new impeller and new wearing rings were put in and the water end was completely overhauled. This did not correct

[1] Prepared under the direction of the Council on Standardization, by Committee No. 7, on Pumping Station Betterments. The personnel of the Committee is as follows: L. A. Day, Chairman; J. N. Chester, F. G. Cunningham, L. R. Howson, and L. A. Quayle.

[2] Chairman of Committee on Pumping Station Betterments; Mechanical Engineer, St. Louis, Mo.

the trouble and it was decided that the steam end or turbine should be looked into. Before taking apart the turbine a duty test was made to determine if there had been any dropping off in efficiency since the acceptance test. In the summer of 1923 the first duty test to check the original trials was made, four years and seven months after the unit was put in service, and we found that the duty had dropped approximately 25 per cent as compared with the original test. It was also impossible to pump more than 95 m.g.d. with all of the nozzles on the turbine open. This condition convinced us that there was something radically wrong with the turbine, since the water end had just been overhauled and was in first class condition.

In an effort to correct the choked-up condition of the turbine (we were positive by this time that the steam end was choked or coated) we undertook to dissolve the foreign matter in the turbine with kerosene. About one barrelful of coal oil was pumped in at the throttle with a steam pump as the machine was being shut down. After the use of coal oil, the unit was again tested, the results showing practically no change in capacity or duty. It was concluded that it would be necessary to take down the steam end of this unit, in order to determine just what had caused the loss in efficiency and ability to carry load. After completely dismantling the rotor about one-half of the buckets in the wheels and guide vanes in the diaphragms were found clogged with scale. Figure 1 shows the scale on one of the wheels thrown outward by centrifugal force and completely blocking the outer half of the blading. Figure 2 shows the scale in the guide vanes which are stationary. The scaling was worst in the first stages.

An analysis of the scale showed the following composition:

| | *Per cent* |
|---|---|
| Silica | 17.7 |
| Iron and aluminium oxides | 13.7 |
| Calcium carbonate | 13.3 |
| Calcium sulphate | 0.8 |
| Magnesium carbonate | 19.2 |
| Magnesium hydroxide | 11.4 |
| Oil | 21.1 |
| Moisture | 2.8 |

It will be noted in this analysis that some of the component matter in the scale was oil. The presence of oil aggravated the accumula-

FIG. 1. SCALE DEPOSIT IN BLADING OF ROTATING ELEMENT

FIG. 2. SCALE DEPOSIT IN RE-DIRECTING VANES ON STATIONARY DIAPHRAGMS

*Test data*

| | TEST 3 | TEST 11 | TEST 13 | TEST 20 | TEST 21 |
|---|---|---|---|---|---|
| Date | April 15, 1919 | June 8, 1923 | Aug. 17, 1923 | Jan. 22, 1924 | Jan. 22, 1924 |
| Duration, hours | 2 | 3 | 3 | 3 | 1½ |
| Water pumped, m.g.d | 101.40 | 94.81 | 94.47 | 99.24 | 105.4 |
| Net head, feet | 65.26 | 65.76 | 66.50 | 64.58 | 64.82 |
| Steam pressure at throttle, pounds gauge | 129.7 | 122.1 | 122.7 | 123.6 | 123.8 |
| Superheat at throttle, °F | 83.8 | 127.4 | 104.2 | 123.7 | 131.3 |
| Vacuum (reference to 30 inch bar), inches Hg | 29.00 | 28.05 | 27.85 | 29.07 | 29.07 |
| Bled steam pressure, pounds gauge | | 32.0 | 27.3 | 4.25 | |
| Bled steam temperature, °F | | 292.0 | 330.0 | 272.0 | |
| Condensate (from primary heater) °F | 73.3 | 100.0 | 101.0 | 56.0 | 58.0 |
| Temperature water pumped °F | 47.0 | 79.0 | 80.0 | 33.0 | 33.0 |
| Main condensate, pounds per hour | 15,433 | 20,207 | 20,426 | 15,039 | 16,743 |
| Bled and auxilliary steam pounds per hour | 1,946 | 1,992 | 2,105 | 2,562 | 782 |
| Total heat to turbine, B.t.u. per hour | 18,696,000 | 24,273,000 | 24,300,000 | 18,860,000 | 20,840,000 |
| Total work done, foot pounds per hour | 2,302,000,000 | 2,169,000,000 | 2,178,000,000 | 2,230,000,000 | 2,375,000,000 |
| Water h.p. | 1,162 | 1,096 | 1,100 | 1,126 | 1,200 |
| Duty foot pounds per B.t.u. (in millions) | 123.2 | 89.4 | 89.7 | 118.2 | 114.1 |
| Pounds steam per water h.p. hr. | 14.93 | 20.28 | 20.47 | 15.63 | 14.6 |

*Data on unit:* In service March, 1919, to October, 1923, a period of four years and seven months, during which it ran 12,230 hours or 30.5 per cent of the time, and pumped 45,000,000,000 gallons against an average head of 59 feet.

Capacity 110 m.g.d. against 65 feet maximum head. Pump, single stage with maximum speed of 352 r.p.m. Turbine, 13 velocity stages, with maximum speed of 3720 r.p.m. Double helical reduction gear, with ratio of 10.56 to 1.

tion of scale by building up a sticky carbonaceous mass. All of the scale forming material, together with the oil, was undoubtedly brought over from the boiler in the steam. In addition to this partial stopping up of the passages there were evidences of cutting action, due, in our opinion, to the erosive action of the solid matter carried in the steam. This cutting action required the replacement of the sealing rings which prevent steam leakage along the shaft, and the reblading of five of the wheels. The high pressure nozzle ring was cut badly, jagged openings having been cut through the thin wall separating one nozzle from the other. This part was also replaced. The wheels which did not require reblading were cleaned with a sand blast, a method which proved to be the best. Soaking in boiling caustic solutions softened the scale, but did not remove it.

After assembling the machine two duty tests were made to determine the gain in economy and capacity. It was found that not only was the full capacity easily obtained, but that the duty had been practically restored as compared with the original tests.

An explanation of the table marked "Test data" follows. The numbers refer to the numbers of the tests.

3. April 15, 1919. One of the acceptance duty tests which represents perhaps the best possible performance of this particular machine under the existing steam conditions.

11. June 8, 1923. The first duty test made to determine the actual loss of capacity and duty. The impeller had been overhauled but the steam end was not investigated. Note that the duty has fallen off approximately 25 per cent as compared with test 3.

13. August 17, 1923. One of several tests made after the steam turbine had been cleaned with kerosene. The duty of the unit remained practically the same.

20 and 21. January 22, 1924. These tests were made after the turbine had been thoroughly overhauled. The duty has been raised from 89 to an average of 116 million foot pounds per B.t.u. This is within 5.5 per cent of the original duty, a very satisfactory performance when it is considered that the impeller by this time had been in use for about three months. Unavoidable errors in observation, it must be remembered, will easily cause 2 to 3 per cent difference in tests of this kind.

In an effort to correct the present conditions we contemplate the use of steam purifiers connected to the boiler outlet nozzles inside the steam drums. It is hoped thereby to eliminate any possibility of the steam carrying foreign matter in an appreciable quantity into the turbine.

It is hoped that this information will not be construed as detrimental to steam turbine driven centrifugal pumps, but that it will point out the importance of investigating any steam conditions which might cause the carrying over of foreign matter into turbines.

Incidentally the importance of test work to determine when extensive repair work should be started and to find out the benefits derived from such work has again been brought out.

# HYDROGEN-ION CONCENTRATION AND SOLUBLE ALUMINIUM IN FILTER PLANT EFFLUENTS[1]

By William D. Hatfield[2]

In 1916 Morison (1) published an article entitled "Dose of alum for clarification of waters." His problem was the clarification of a turbid river water, using aluminium sulfate and intermittent twenty-four hour sedimentation periods. From beaker experiments and practical plant operation covering a period of two years, he found that the best results, in clarification, bacteria removal and absence of residual alum in the tap water were obtained when sufficient alum was added to just neutralize one-half the alkalinity of the raw water. He concluded:

1. The alum dose in parts per million should be 1.1 times the alkalinity (expressed as p.p.m. $CaCO_3$).
2. This dose is independent of the turbidity and absolutely dependent on the changes in alkalinity.
3. This treatment is the optimum treatment for complete insolubility of the aluminium hydroxide floc.
4. With treatments of alum greater or less than 1.1 times the alkalinity, soluble aluminium could be demonstrated in the tap water with hematoxylin solution.
5. In the operation of MECHANICAL FILTRATION PLANTS less alum may be used and an aluminium free effluent may still be obtained, because the aluminium hydroxide mat on the filters removes colloidal aluminium sol in the process of filtration.

The following quotation from Morison's article anticipates our present interest in hydrogen ions, and throws some doubt on the accepted mechanism of colloidal precipitation in water purification.

In one respect the writer is unable to bring the above experiments into line with the theory of colloids . . . . ; The optimum dose, the so-called isoelectric point, has been shown in these experiments to be independent of the

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 25, 1923.

[2] Chemist, Sewage Treatment Plant, Sanitary District, Decatur, Illinois.

amount and nature of the colloid present. (The optimum point can be moved at will by altering the alkalinity of the water, and when the alkalinity remains constant the optimum point is apparently uneffected by qualitative or quantitative changes in the colloids.) It would seem as if the precipitation of the colloids were not so much due to the neutralization of the charge on the sol by that on another sol or electrolyte, as to a certain balancing of the acid and basic ions in solution.

It is interesting to apply the Greenfield-Baker (2) equation for calculating the pH of water to Morison's suggestion. If the isoelectric point is when the alkalinity is half neutralized, then the concentrations of $CO_2$ and $CaCO_3$ (alkalinity) in the treated water will be equal and will cancel in the equation, and the pH value in any water at the isoelectric point will be 6.5.

$$(H^{\cdot}) = \frac{3 \times 10^{-7}\ (CO_2)}{(\text{alk.})} + 1 \times 10^{-6}$$

$$= 3.1 \times 10^{-7}$$

$$pH = 6.5$$

The concentration of $CO_2$ originally in the raw water is neglected in this calculation because no data were available. The small amount of probable $CO_2$ in surface waters, however, would not reduce this figure much more than 0.2 to 0.3 of a pH unit.

Hatfield (3) has shown that reasonably good coagulation of a water with variable alkalinity always begins at a pH value of 7.6 to 7.8, providing the original pH of the water was higher than 7.8; also that this coagulation point was independent of the turbidity. He found that the most efficient point to operate the Highland Park Filtration plant was at a pH value about 7.2. When larger amounts of alum were used to reduce the pH of the treated water below 7.2 too much floc was thrown on the filters and their period of service was shortened. Data given in this paper extend the optimum coagulation and sedimentation zone given in the earlier paper, from the range 6.5 to 7.6 to the range 5.8 to 7.5 pH units.

Buswell and Edwards (4) have shown that, with few exceptions, the effluents from the filter plants in Illinois contain less aluminium than their raw waters respectively, and that the pH values of the effluents range from 6.0 to 7.7 pH units. They contend that, though the curve plotted with pH values and $Al_2O_3$ in the effluents is not a smooth curve, nevertheless the points trend toward a minimum

$Al_2O_3$ content at a pH of 6.0. Although this statement is true, it happens that the raw waters of those sources which had an effluent of about pH 6.0 contained, with one exception, less $Al_2O_3$ to start with than the effluents of the other plants. Their data, therefore, do not show that aluminium hydroxide under the condition of filter plant operation is any more insoluble at pH 6.0 than at pH 7.7. A plot of the decrease in the determined $Al_2O_3$ between the raw waters and the respective effluents and the pH values do not show that the pH value has any definite effect on the amount of removal of the aluminium which was originally dissolved in the raw water.

Theriault and Clark (5) have shown that from the known acid and basic dissociation constants of aluminium hydroxide, the calculated isoelectric point in dilute solutions is 5.49 or 5.6. They have shown numerous curves plotted on pH-time bases which indicate that, as the amount of alum used approached that usually consumed in water purification plants, the apparent isoelectric point approached 5.5 pH units. Another pH-time curve, where the alum dose was constant and the buffer value varied, gives an apparent isoelectric point at pH 5.9. Their results indicate that, as the solutions become sufficiently dilute to approach the salt concentration of normal surface waters, the isoelectric zones of the pH-time curves become very narrow and the isoelectric point is very definite.

The pH-time curves, similar to those of Clark's, given in this paper were determined on Lake St. Claire water using "filter alum" and the apparent isoelectric point is at pH 6.1 to 6.3. The pH-soluble $Al_2O_3$ curves were determined on the same water using filter alum and filtering the treated water through the Highland Park mechanical filtration plant or through qualitative filter paper in the laboratory. In these curves the isoelectric zone (minimum solubility zone for $Al(OH)_3$) extends from 5.9 to 7.4 pH units. The differences between Dr. Clark's and these results are probably due to the impurities of a natural water with its dissolved neutral and buffer salts, turbidity and organic matter. The wide aluminium-insoluble zone which I report is probably due to the factor mentioned by Morison, i.e., the effect of mechanical filtration on the removal of colloidal aluminium sol.

During the summer and early part of the fall of 1922 samples of the raw water and the combined effluents were collected during

different alum treatment rates. Liter samples were evaporated, silica removed and iron and aluminium determined as the oxides, according to the A. P. H. A. standard methods. Iron was determined colorimetrically in a separate sample, calculated to ferric oxide and subtracted from the combined ferric and aluminium oxides. In table 1 will be found the results of this series of experiments; while curve I, figure 1, gives the pH-soluble $Al_2O_3$ data in graphic form.

These data bring out two interesting facts: first, that, when the water is treated with 0.65 grain per gallon or more of alum at a resulting pH of 7.5 or less, the effluent contains less $Al_2O_3$ than the raw water (confirming Buswell and Edward's earlier data); and second, that, at a treatment of 0.27 grain per gallon and a pH of

TABLE 1

*Residual aluminium in the effluent from the Highland Park Filters*

| SOURCE | ALUM TREATMENT | pH VALUE OF SAMPLE | $Al_2O_3$ AND $Fe_2O_3$ | $Fe_2O_3$ | $Al_2O_3$ | $Al_2O_3$ IN RAW WATER PLUS ADDED $Al_2O_3$ |
|---|---|---|---|---|---|---|
| | *grains per gallon* | | *p.p.m.* | *p.p.m.* | *p.p.m.* | *p.p.m.* |
| Raw water | 0.00 | 8.1 | 1.6 | 0.36 | 1.24 | 1.24 |
| Effluent | 0.27 | 7.8 | 3.2 | 0.03 | 3.17 | 2.01 |
| Effluent | 0.50 | 7.6 | 2.6 | 0.03 | 2.57 | 2.66 |
| Effluent | 0.65 | 7.5 | 0.8 | 0.03 | 0.77 | 3.09 |
| Effluent | 0.80 | 7.4 | 1.1 | 0.03 | 1.07 | 3.52 |
| Effluent | 0.96 | 7.3 | 1.0 | 0.03 | 0.97 | 3.97 |
| Effluent | 1.25 | 7.1 | 0.8 | 0.01 | 0.79 | 4.08 |

7.8, the water actually has a solvent action on the aluminium floc already in the coagulation basin and on the filters, for the effluent contains 3.17 p.p.m. $Al_2O_3$, compared to the total of only 2.01 p.p.m. $Al_2O_3$ in the water after treatment with the alum. From the standpoint of residual alum in the effluent of the Highland Park Plant, it is quite clear that the mimimum allowable dose is about 0.6 grain per gallon of alum. More alum than this minimum is sometimes necessary to remove high turbidities. The question now rises as to the maximum amount of alum that can be used before soluble aluminium is found in the effluent. How would curve I look if completed with higher alum treatments?

The cost of operating the plant at higher alum treatments to satisfy our curiosity was out of the question, so I resorted to labora-

tory methods in order to get data for curves showing alum treatments of the Lake St. Claire water from 0 to 15 grains per gallon. In the following experiments 2 liters of water were treated with a freshly prepared solution of alum, mixed, coagulated and settled for five hours, and filtered through two 10-inch qualitative filter papers. The filtered samples were analyzed according to the methods described above and the results are given in table 2.

Curve II, figure 1, plotted on pH-soluble $Al_2O_3$ bases from data in table 2 shows that, under the laboratory conditions of these

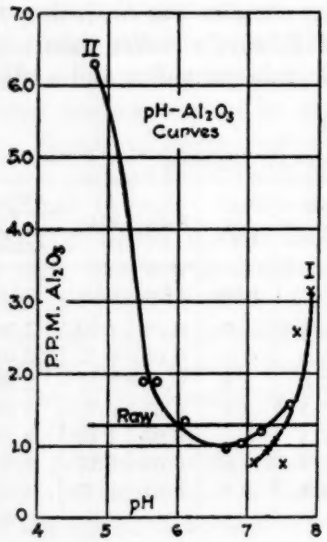


FIG. 1

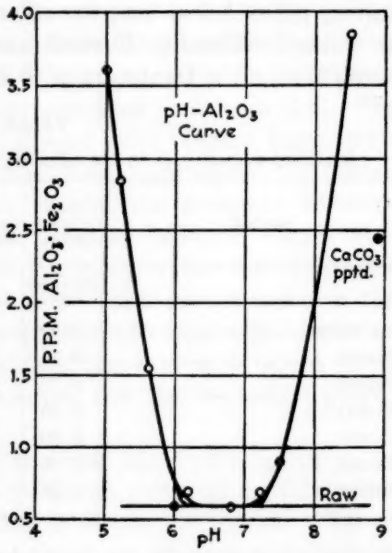


FIG. 4

tests, there is a zone reaching from pH 5.9 to 7.3 in which the effluents contain less aluminium than the raw water. The broken line curve I, plotted from similar data in table 1, shows that in actual practice of mechanical filtration a larger amount of aluminium is removed from the water than by the laboratory filtration through filter paper and that the zone of "less aluminium than in the raw water" is widened to about pH 7.5. It is equally possible that, if the plant experiments included treatments to 15 grains per gallon, the lower extremity of this zone would be about 5.7. A comparison of curves I and II show a sufficiently close relationship between the

laboratory bottle experiments and those of actual plant operation to justify accepting the former results as applicable to practice.

In figure 2 the time, in minutes, required for the first visible floc formation is plotted against the pH values obtained by treating the raw water with from 0 to 15 grains per gallon of filter alum. This curve represents somewhat the same conditions as Clark's pH-time curves mentioned above, except that the aluminium content is variable instead of constant. It does approximate operation conditions more than the Clark curve. Figure 2 shows a minimum, or apparent, isoelectric point at pH 6.3. The curve is not symmetrical because at the lower pH values, where larger quantities of

TABLE 2

*Aluminium in filtered waters treated in the laboratory*

| ALUM | pH VALUE | FILTERED SAMPLE | | | |
|---|---|---|---|---|---|
| | | $Al_2O_3$ and $Fe_2O_3$ | $Fe_2O_3$ | $Al_2O_3$ | Hematoxylin test |
| *grains per gallon* | | *p.p.m.* | *p.p.m.* | *p.p.m.* | |
| 0.00 | 7.8 | 1.3 | 0.02 | 1.28 | − |
| 0.25 | 7.6 | 1.6 | 0.02 | 1.58 | +++ |
| 0.75 | 7.2 | 1.2 | 0.00 | 1.20 | + |
| 2.25 | 6.9 | 1.2 | 0.07 | 1.13 | Faint |
| 4.00 | 6.7 | 1.1 | 0.13 | 0.97 | − |
| 7.00 | 6.1 | 1.4 | 0.16 | 1.34 | − |
| 10.00 | 5.7 | 2.3 | 0.40 | 1.90 | + |
| 12.50 | 5.5 | 2.4 | 0.50 | 1.90 | −(?) |
| 15.00 | 4.8 | 7.2 | 0.93 | 6.27 | +++ |

alum are used, the forces of mass action cause the floc to form sooner than when smaller concentrations of alum are used.

In the above experiments the pH value was varied by adding different amounts of alum to the raw water. In the following set of experiments the pH value of the water was varied from 3.3 to 9.7 by adding the necessary amounts of sulfuric acid or sodium hydroxide to the raw water. Four liter samples of these waters were then treated with 1 grain per gallon of alum in 4-liter glass-stoppered bottles and coagulation noted hourly. At the end of seventy-two hours equilibrium seemed to be complete; the samples were filtered through 10-inch qualitative filter papers and the aluminium and iron oxide content determined on 2-liter samples. Cor-

rection for iron oxide in these samples was constant at 0.03 p.p.m. and is neglected in the data on this series tabulated in table 3.

The pH-time curve in figure 3, plotted from data in table 3, shows its minimum distinctly between 6.0 and 6.2 pH units, thus indicating 6.1 as the apparent isoelectric point, if this time method

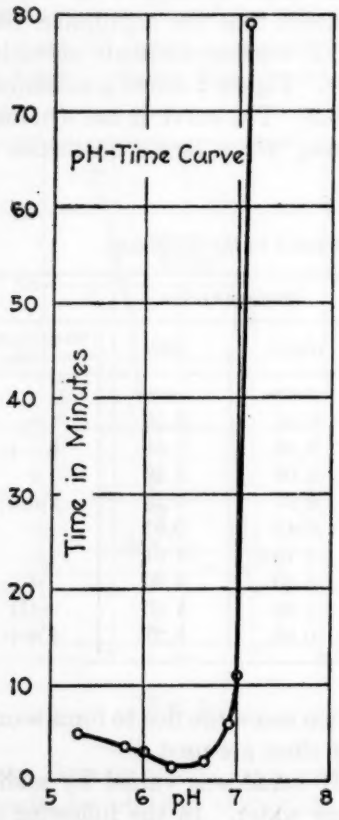


FIG. 2

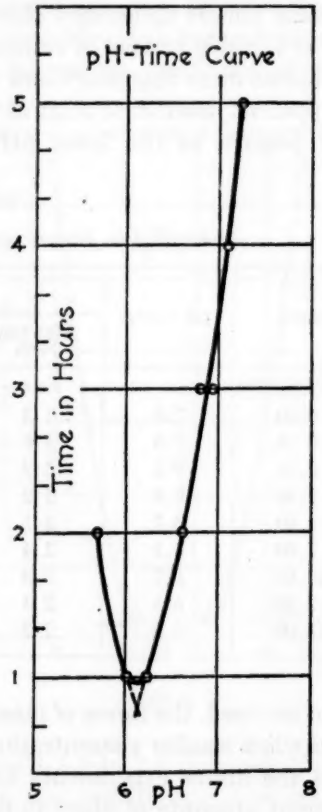


FIG. 3

indicates such a point. The pH-soluble $Al_2O_3$ curve in figure 4, plotted from data in table 3, shows the minimum solubility zone to extend approximately from pH 6.0 to 7.4.

The data in table 3 clearly indicate the possibility of acidifying water in conjunction with alum treatment. The relative costs of alum-acid treatment and alum treatment alone should be carefully

studied on large scale operations, so I have refrained from calculating costs from my small scale experiments. The use of acid alum is not advisable because acid alum is hygroscopic and would be very unsatisfactory to ship or handle. Ground acid alum for dry feed machines would become sticky,badly caked, and would rapidly destroy the bags in which it is shipped. From every point of view it would be more satisfactory and more scientific to use neutral or

TABLE 3

*Effect of acid and alkali on coagulation of water, alum at 1 grain per gallon*

| pH VALUE OF RAW WATER BEFORE ADDITION OF ALUM | pH VALUE 3½ HOURS AFTER ADDITION OF 1 GRAIN PER GALLON ALUM | FIRST APPEARANCE OF FLOC | pH VALUE OF SAMPLES AT TIME OF FILTRATION (72 HOURS) | $Al_2O_3$ AND $Fe_2O_3$ | EXCESS $Al_2O_3$ AND $Fe_2O_3$ OVER THAT IN RAW WATER | QUANTITATIVE HEMATOXYLIN TEST* |
|---|---|---|---|---|---|---|
| | | *hours* | | *p.p.m.* | *p.p.m.* | *p.p.m.* |
| 9.7 | 9.3 | | 8.95 | 2.45 | 1.85 | 1.5 |
| 9.4 | 9.0 | 72 | 8.5 | 3.85 | 3.25 | |
| 8.9 | 8.1 | 22 | 8.0 | 1.9 | 1.3 | 1.3 |
| 8.2 | 7.2 | 5 | 7.5 | 0.9 | 0.3 | |
| 7.8 | 7.2 | 5 | 7.2 | | | |
| 7.7 | 7.1 | 4 | 7.2 | 0.7 | 0.1 | 0.1 |
| 7.4 | 6.9 | 3 | 7.1 | | | |
| 7.0 | 6.8 | 3 | 7.0 | | | |
| 6.7 | 6.6 | 2 | 6.8 | 0.6 | 0 | 0 |
| 6.4 | 6.2 | 1 | 6.4 | | | |
| 6.1 | 6.0 | 1 | 6.2 | 0.7 | 0.1 | 0 |
| 5.9 | 5.7 | 2 | 6.0 | 0.6 | 0 | 0 |
| 5.6 | 5.6 | 72 | 5.6 | 1.55 | 0.95 | 0 † |
| 5.4 | 5.1 | | 5.2 | 2.85 | 2.25 | 0.4† |
| 4.8 | 4.7 | | 5.0 | 3.6 | 3.0 | 2.0† |
| 3.8 | 3.8 | | 3.8 | 3.75 | 3.15 | |
| 3.3 | 3.3 | | 3.3 | 4.25 | 3.65 | 2.0† |
| Raw water untreated with alum..... | | | 7.7 | 0.6 | 0 | 0 |

* 1 cc. 1:1000 aqueous solution Hematoxylin in 50 cc. sample of water plus 1 cc. saturated ammonium carbonate solution. Allow fifteen to twenty minute for color formation and compare with standards prepared *at the same time* using raw water filtered through a Berkefeld filter, instead of distilled water, and standard filter alum solution. Compare in Nessler tubes viewing the color from the side rather than through the length of the tube.

† This discrepancy in the gravimetric and colorimetric results needs further study. The color method is of course questionable, but there is little doubt that the gravimetric results are too high in this acid region. (Compare with qualitative hematoxylin test in table 2.)

slightly basic alum and apply the acid separately as sulfuric or carbonic acids.

In the practical operation of a mechanical filtration plant it seems, as yet at least, that the isoelectric point of aluminium hydroxide in itself is only of theoretical value, because the complete removal of bacteria, turbidity, color and added aluminium ions is in most cases obtained long before the so-called isoelectric point is reached. It would often be most uneconomical to add enough alum to bring the pH value of the treated water to 6.1, or to 5.5 if you prefer Clark's data. On the Lake St. Claire water 0.6 grain per gallon of alum is usually sufficient to produce the desired results, but it would require 7 and 12.5 grains per gallon to reduce the water to the pH values of 6.1 and 5.5, respectively.

On the other hand the pH-soluble $Al_2O_3$ curves give us valuable information. In the first place there is shown an optimum pH zone within which, for all practical purposes, soluble, free, aluminium ions do not exist in the effluent. In the second place, the point at the end of this optimum zone which indicates the minimum amount of alum and the corresponding pH value at which complete removal of added aluminium takes place, is of considerable importance to the operator. It is at this "minimum optimum point" that he will operate whenever the conditions of the raw water allow it. When higher pollution, turbidities, and color require more alum for their removal, the operator will simply use that amount of alum which experience has taught him to use, knowing that when he reaches the lower pH end of the optimum zone more alum means lime or soda ash to take care of the excess alum by keeping the pH in the optimum zone.

Results on Lake St. Claire water and artificially prepared waters in this laboratory indicate that this optimum zone extends from about 5.8 to 7.5 pH units, and although this zone may shift one way or the other in some waters, I am inclined to believe that in the majority of cases it will hold within one or two-tenths of a pH unit. In cases where the pH value of the raw water is low, for example, 6.8, it will be necessary to add enough alum so that the forces of mass action will start the reaction in sufficient time for coagulation and sedimentation to take place before filtration, and therefore the pH value of the "minimum optimum point" of treatment will be less than that of the raw water and the zone of optimum treatment will be narrower than with the more alkaline waters.

A very soft water having very little dissolved buffer salts might have an initial pH of 7.0, but the addition of a small amount of alum would make the treated water too acid, and therefore require artificial alkalinity. The methyl orange alkalinity is a rough measure of this buffer value and for that reason is an indispensable determination until a better method is developed.

This wide zone of treatment has been the salvation of filter plant operators for the last 20 or more years. Think what would have been the efficiencies of past operation, if it had been necessary to treat each water to the exact isoelectric point, be it Clark's 5.5 or Hatfield's 6.1, when they did not know what a pH unit was.

## SUMMARY

1. Curves plotted according the Clark's pH-time method from data obtained by treating Lake St. Claire water with alum, show an apparent isoelectric point for aluminium hydroxide under these conditions at 6.1 or 6.3 pH units.

2. Curves are given which show that in filtration the effluents from alum-treated waters are practically free from all the aluminium added as alum when the pH value of the treated water lies in the zone between 5.8 and 7.5 pH units. Mechanical filtration plants operating within this zone will probably not only remove all the added aluminium but also some of the aluminium naturally dissolved in the raw water.

3. A water which has been under-treated with alum and has a pH value of more than 7.5 may have a solvent action on the floc in the sedimentation basin and on the filters such that the effluent will contain more aluminium than that in the raw water plus that added as alum. This is probably also true of an over-treated water.

4. It is firmly believed that the importance of hydrogen-ion concentration has been established in water work and that each year it will be applied more and more to practice.

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# TYPES OF PIPE FOR WATER MAIN CONSTRUCTION[1]

By S. B. Morris[2]

## HISTORY

Development and improvement in the art of manufacturing and laying pipes for the conveyance of water dates back to early Babylonian days, 4000 years B.C., and is still engaging the minds of manufacturer and user alike. The pipe used by this early civilization was a very crude clay pipe or was composed of stone blocks through which cylindrical holes had been cut. Lead pipes were extensively used by the Romans for distributing water. In the Middle Ages bored logs or lead pipes were used for conveying water. Modern water pipes are made of cast iron, wrought iron, steel, lead, wood, vitrified clay, cement or concrete. In the far east bamboos are still largely used for water pipes of small diameter.

## WOOD STAVE PIPE

The first log pipes in America were laid in 1652 for the water works of Boston. These were replaced in 1796 after one hundred forty-four years of service with new log pipes which continued in service until about 1848 when they were replaced with cast iron pipe. Wooden pipes are still being constructed and used to carry water, but it is now the practice to build all pipes larger than 6 inches of wooden staves wrapped with heavy wire or bands. In order to protect the steel wire from corrosion the exterior is usually coated with asphaltum. While wooden mains can be easily tapped under pressure, their use has been substantially given up for distributing purposes and is now largely confined to supply mains, conduits, siphons, and penstocks of large diameter. Wooden pipe lines have the advantage of high carrying capacity which does not decrease with age as in the case of all metal pipes. In heavy soils the wood is very durable, but in dry light sandy soil their life is much shorter.

[1]Presented before the California Section meeting, October 26, 1923.

[2]Chief Engineer, Water Department, Pasadena, California.

## CAST IRON PIPE

Cast iron pipe is said to have been first used in England in the fourteenth century. However the oldest cast iron mains now known to exist are 13 to 20 inches in diameter and were laid by order of Louis XIV of France, to supply the town and parks of Versailles from the reservoirs of Picardie. These pipes are in lengths of 1 meter and are joined by means of bolted flanges.

The first bell and spigot cast iron pipe was designed by Thomas Simpson, Engineer of the Chelsea Water Company of London, and was laid in 1785 in 6-foot lengths. The cities of America did not know cast iron pipe until 1817 when the first cast iron pipe in 9-foot lengths was imported from England and laid in Philadelphia. Some of this bell and spigot pipe is now in use after one hundred years of service.

In the past one hundred years the chief evolution in the manufacture of cast iron pipe has been in the introduction of the modern blast furnace and cupola, the use of flux and the improvement of cores permitting longer lengths to be cast. We have stepped from the 1 meter to the 6-, 9- and 12-foot, and within the past ten years, in sizes up to 12 inches, to 16-foot pipe and in some foundries on account of foreign demand to 5 meter (16 foot 4½ inch) lengths. The advantage of the longer lengths in saving bell holes, jointing material, labor and in lessening leakage is obvious.

By 1902 the New England Water Works Association had adopted standard specifications for the manufacture of cast iron pipe, thus putting all manufacturers on an equal footing. This specification however included 10 different thicknesses of pipe for the various pressures. The American Water Works Association adopted specifications May 12, 1908, and reduced the number of weights to 8, only 4 of which are in common use. With decreasing manufacturing costs and price of pig iron, the thinner sections of the New England Water Works Association were given up.

With the greatly increased cost of pig iron, the high freight rates and the sale price of cast iron pipe there grew up during the war a demand for lighter, cheaper pipe. The first response to this new condition was the adoption of higher tensile strength metals by several of the cast iron pipe companies. However, the saving following the slight price recession since the war did not warrant the continuance of these pipes which were only slightly lighter than Standard American Water Works Association pipe and the cost was greater per ton.

The standard practice is now to pour all American Water Works Association pipe vertically in dry sand moulds. Pipe 12 inches and smaller is usually cast bell end up, while larger sizes are cast bell end down. On the larger pipes the spigot ends are cast long and trimmed off to secure sound metal.

Moulding sand is tamped either by machine or by hand around a pattern and within a steel flask. After the pattern is removed the sand is coated with a metallic blacking and dried over gas heaters. The core is made by revolving by power an iron spindle which is to form the center of the core. A twisted hay or excelsior rope is first wound around the spindle. The mud which is mixed in a pug mill is plastered over the hay rope and trued up with a strike. The core is then baked and the final coat of mud applied and again baked and coated with blacking. If it were not for the hay it would not be possible to withdraw the core after the pipe is poured due to the shrinkage of the metal about the core.

### DE LAVAUD, CENTRIFUGALLY CAST, CAST IRON PIPE

During the past year the leading cast iron pipe company in America has brought out and offered to the public in commercial quantities a new cast iron pipe, being a radical departure from former standard practice. This pipe is cast centrifugally without a core, by what is known as the de Lavaud process. It was my good fortune last January to inspect this process at Birmingham before placing an order for some 1500 tons of pipe, which is made in diameters varying from 6 to 12 inches.

In the de Lavaud process molten metal is poured into a steel mould of proper diameter revolving in a water jacket. The only core used is a sand core supported on a steel mandrel to form the bell end. A lip over 12 feet long is provided so that the flowing metal is poured first into the bell end after the revolving mould has been brought up to speed. The lip is then slowly withdrawn toward the spigot end, the speed of the mould, the rate of withdrawal of the lip, and the tipping of the ladle of moulten iron all being synchronised so as to give a pipe of proper thickness. The pipe solidifies immediately and is pulled out of the mould from the hub end while still red hot and calipered and weighed, after which it goes to an annealing oven maintained at 1700°F. It is necessary to anneal the pipe to overcome its brittleness from the sudden cooling. While passing through the oven the pipe is rotated to give uniform temperature on all sides.

The de Lavaud pipe is very uniform in cross section, is fine close grained and of higher tensile strength and, therefore, is made thinner for the same pressures than the American Water Works Association standard cast iron pipe.

The annealing does not wholly overcome the tendency of the pipe to be brittle. In laying a good many miles of this pipe we have found that the pipes could be cut much more effectively with rolling cutters than with the ordinary cold cutter. Our experience is that the de Lavaud pipe taps very well and takes an excellent thread. We have found it very difficult to detect all breakage when unloaded from the cars due to the fineness of the cracks and considerable cutting has had to be done on the ditch when it was too late to secure acknowledgments from the carriers.

### McWANE, HORIZONTALLY CAST, CAST IRON PIPE

A new development during the past year is the *McWane Pipe*, which is cast horizontally in a green sand mould in 5-foot lengths in diameters from $1\frac{1}{4}$ to 6 inches, and in 5 to 12-foot lengths in 4- and 6-inch pipe. In marketing a thinner lighter pipe than the American Water Works Association standard, the manufacturers of this pipe claim added strength due to the increased depth of the skin obtained by using a green sand mould. This pipe is cast without any bead on the spigot end and with bell end similar to the American Water Works Association specification. To protect the pipe in transit the spigot end is cast a little thicker than the rest of the pipe. This has apparently been successful as the amount of broken pipe received by us in Pasadena by boat and rail is so far less than with other grades of cast iron pipe.

Pipe is furnished either with or without a prepared lead and steel wedge joint. In small sizes it is furnished with two 5-foot pieces with center joint precaulked. Some pipe with center joint of cement has been shipped with success. The smaller pipe is also made with screwed ends so as to connect to ordinary standard screw fittings.

In order to prevent movement of the core when pouring the 12-foot pipe the core is supported near its midpoint by copper chaplets shaped like a collar button with two intermediate corrugations to prevent the copper from being later forced out of the pipe. After the pipe is cast a workman expands this copper chaplet by means of a center punch and hammer. In several thousand feet of this pipe we have so far had two leaks at these copper chaplets. Such leaks can readily be stopped by application of center punch as noted above.

### UNIVERSAL CAST IRON PIPE

Another type of cast iron pipe which has been on the market for a number of years is Universal Cast Iron Pipe which is cast horizontally in 6-foot lengths. This pipe has a ground tapered joint and is bolted together with two bolts and without any gasket.

Great flexibility is claimed for this pipe and after being laid in firm ground will not leak after the bolts have rusted out. Universal pipe is made in sizes from 2 to 20 inches and for pressures from 100 to 250 pounds per square inch.

### SIMPLEX CAST IRON PIPE

This pipe is quite similar to the Universal, but is bolted together with a prepared joint with lead and jute endless ring gasket for gas or water lines. Pipe varying from 2 to 6 inches in diameter and 5 feet in length is made, but it is not intended for competition with the American Water Works Association standard pipe. It is rather a combination of flanged and bell and spigot joints giving great flexibility. Special fittings with bolts and lugs are provided for use with Simplex pipe.

### LAP WELDED STEEL PIPE

The general use of lap welded steel pipe except in the smaller water works systems is becoming less common than it was a few years ago. In the distributing systems of the ten water companies which have been consolidated into the Pasadena City System we have many miles of standard screw, casing screw, old boiler tubes with welded joints, and Matheson joint pipe. I believe everyone is familiar with the use of lap welded standard screw pipe which goes by inside measurement and in sizes above 2 inches has 8 threads per inch and in the casing screw pipe which is sold by outside diameter is lighter in weight and has more threads per inch. For protection from corrosion these pipes are either galvanized, dipped, or dipped and wrapped with roofing paper. Screw pipe comes in random lengths varying from 18 to 22 feet.

Lap welded pipe with welded joints is becoming very largely used for gas, but so far has not been very widely used for water. This pipe comes in lengths of 30 feet or more.

Matheson joint pipe is sold in the same weights as casing and goes by outside diameter. It has a bell and spigot joint similar to cast

iron pipe, but requiring much less lead. It is sold in random lengths of 10 to 20 feet. It has an advantage over screw or welded joint pipe in that it can be made to give high resistance to the flow of stray currents by using cement joints, thus minimizing electrolytic damage.

### RIVETED STEEL PIPE

Riveted steel pipe was first used in California about 1852 in the hydraulic mines. Use of riveted steel pipe for water works purposes was begun soon afterward. Our fellow member Mr. Elliott reports that a 30-inch No. 12 gauge riveted iron pipe fifteen miles long was laid by Mr. Hermann Schussler for the Spring Valley Water Company in 1868, some of which continued in full service until 1922 or for fifty-four years.

In the early development of water works in California little cast iron pipe was used owing to its prohibitive cost. At a very early date riveted steel pipe with drive joints and in diameters from 3 to 36 inches was developed with much success. In fact many cities and water companies are still using riveted steel mains for water distribution.

Pasadena first used riveted steel with drive joints in 1884 and much of this pipe is still in use after nearly forty years of service. This pipe is manufactured in random lengths of about 20 feet and is composed of steel sheets 30 to 60 inches in length. Pipe is usually made with single riveted seams up to 6 inches and in larger sizes with double riveted longitudinal seams and single riveted circular seams. The drive joint is 3 to 4 inches in length made by slightly belling the female end and tapering the male end. The rivet heads on the outside of the male end and the inside of the female end must be well ground off and the lap in the sheet well scarfed so the joint will drive readily and make tight.

Pipe is dipped in heavy "D" grade asphaltum of penetration varying with the season in which it is to be laid and in many cases in recent years wrapped with mica covered roofing paper. A stream of hot asphalt is fed in under the paper in addition to the original dip on the pipe thus giving a thick protective coating which on account of the paper is not easily chipped off in laying. After the pipe is placed in the trench gasoline or kerosene is squirted onto the pipe ends and ignited so as to melt the dip. As soon as the dip begins to run the pipe is driven home with a maul in sizes up to 8-inch and with a heavy ram against a steel driving plate in larger sizes.

Pasadena has over 100 miles of riveted steel pipe, 4 to 30 inches in diameter, in its distributing system, all of which has been laid with drive joints. With the exception of one 24-inch line having defective joints we have never had any trouble with leakage at the drive joints. The thickness of our pipes varies from No. 18 to No. 10 gauge.

This pipe is so cheap and economical to lay that we would be using it on much of our new work, if it were not for the expensive pavement which is now being generally used adding to the cost of replacement when this is necessary.

Many water works have given up the drive joint and are laying riveted steel pipe with welded joints and others are using riveted field joints in sizes 20 inches and larger. Drive joints are not generally used with any pipe thicker than No. 8 gauge. Present use of welding apparatus has greatly simplified the installation and locating of fittings as these may now be built up by the water works themselves and outlets placed on the lines wherever needed.

### CONCRETE PIPE

This material has generally been used only for supply conduits, although there are now several instances where reinforced concrete is being used for larger mains in water works distributing systems. Concrete pipe has generally been tamped into steel forms and in lengths from 3 to 4 feet. Concrete mixtures have generally varied from $1\frac{1}{2}:1:2\frac{1}{2}$ to 1:2:4. Many types of joints have been used varying from bell and spigot to various interlocking poured joints. Obviously the very short lengths have added greatly to the expense of laying.

Recently there has come onto the market 12-foot lengths of reinforced concrete pressure pipe in sizes from 12 to 72 inches in diameter. Three types of reinforced concrete pressure pipe are now being manufactured in these 12-foot lenths. Cylinder pipe with a welded steel cylinder running through the entire length of the pipe and incased in reinforced concrete; poured pipe with bar and mesh reinforcement; and centrifugal pipe made by revolving a mould at high speed causing the concrete, reinforced with bars or mesh or with both, to take its form by centrifugal force. The reinforcement is figured to stand the full hydrostatic head with a unit stress of 10,000 to 12,000 pounds per square inch without giving any tensile value to the concrete. Various steel and lead joints are provided for these pipes.

In the centrifugal concrete pipe the mould revolves at about 2000 feet per minute, rim speed. The impurities and excess water are removed from the interior surface while the pipe is still revolving. Pipes from 12 to 36 inches in diameter are being made. A 24-inch pipe, 2½ inches in thickness, must be revolved for fifteen to twenty minutes. The steel moulds are left on the pipe over night and the pipe cured for six to seven days submerged in water.

Outlets can be provided in the manufacture of this pipe by which it may be tapped under pressure. Centrifugal concrete pipe is successfully being used for pressures up to heads of 200 feet. Price of this pipe was quoted to me in June as about the equivalent of cast iron laid, exclusive of trenching and backfilling, at a price of $45.00 to $50.00 per ton.

In the hillside service of many of our cities it is believed there is opportunity for use of large diameter moderate pressure pipe in the lower pressure limits for which concrete pipe may be used These new developments should be watched with interest by all water works men. In East Orange, New Jersey, a 20-inch pipe recently laid by Nicholas S. Hill, past president of this Association, showed a leakage of only 90 gallons per inch diameter per mile per day.

From the foregoing brief discussion of the various types of pipe being manufactured for water works distribution purposes there is to be noted a greater tendency to produce new and lighter types of pipe to lessen the high cost than has occurred for generations of pipe manufacture. The user of pipe has welcomed these new ideas in the present congested market of little competition. He must study, test and inspect this new pipe, however, very carefully before purchasing it in large quantities.

# EFFECT OF DISTRIBUTION SYSTEM DESIGN UPON FIRE INSURANCE RATES[1]

By Louis Stocklmeir[2]

Before commenting upon the distribution design and its effect upon fire insurance rates, it might be well to dwell for a few moments upon the question of how our fire insurance rates are made up, for no doubt there exists in the minds of many people, not directly connected with the insurance world, a somewhat hazy conception as to what constitutes these rates.

Rates promulgated by a bureau usually cover the following features: structures and their contents; rents and rental values; explosion, riot, and civil commotion; use and occupancy; earthquakes; tornado, cyclones and windstorm, growing crops, etc. Each and every one is usually arrived at in a different manner, yet it may possibly be that the formation of a rate is dependent upon another rate, for example, the building fire rate directly affects the contents rate for that building.

Consequently, on account of different methods used for arriving at rates pertaining to the features mentioned above, I shall purposely omit all features of insurance, other than methods of fire rate making on buildings. This will simplify the discussion and provide the best example as to methods used. Buildings regardless of location may be divided into the following general groups:

Class A. Independent steel supporting structure, fire proofed.

Class B. Structure of fire resistant materials, usual form being a reinforced concrete building.

Class C. Outer walls of fire resistant materials, usually brick or reinforced concrete, with wood interior construction.

Class D. Frame.

As addenda to the foregoing general classes, there may be: tile; all steel and mill classifications; iron clad on wood; stucco; brick veneer, etc.

[1] Presented before the California Section meeting, October 26, 1923.

[2] Engineer, Pacific Board of Fire Underwriters, San Francisco, Calif.

It is obvious that each of the general classifications have distinctive merits or deficiencies of their own, and having such, the same should be reflected upon the fire insurance rates; consequently it would naturally follow that the gradation of rates from a basic standpoint only would be in an upward direction from class A to class D. However, the question arises why are final rates sometimes lower on a class C than on a class B building? The answer is that the following features have a tremendous effect on the fire rate, namely, occupancy, building deficiencies, and exposures. I shall endeavor to show this effect more clearly later in the paper.

Our rates may be divided roughly into two groups: (*1*) tariff rates; (*2*) specific rates. These rates are based on the assumption that an assured will insure at least 50 per cent to value, and in cases on certain buildings, should more insurance be carried, there is a corresponding decrease in the rate, and if not that much is carried, provisions are made for a corresponding increase.

1. Tariff rates as a rule are made up by bureaus on information furnished by representatives of companies, authentic maps, etc. This rate may or may not be the final rate, depending chiefly on the occupancy and classification of the risk being insured.

2. Specific rates, on the other hand, are rates based on the personal investigation of the risk in question by some representative of the rating bureau. These rates are usually formed by modification of tariff rates or by the application of special schedules.

To show more clearly the method of tariff rate making, there has been prepared for convenience of application a tariff book in which are listed practically all known occupancies, alphabetically arranged. Following each occupancy and for different building classifications are charges in dollars and cents per 100. These charges vary with the class of building and the occupancy hazard of the building. In this tariff are found also charges and credits for building's deficiencies, together with exposure charges for buildings adjoining or in the vicinity of the risk to be rated. These exposure charges naturally are directly affected by the class of exposing building, its occupancy and the intervening distance. With the above general outline of method of rate making, how is this system applied to towns of various classes, so that buildings in each town will receive their just rates as compared with those in another town. For we know that towns may range in many features from poor to excellent when comparisons are made. In addition, what effect has the water supply and distribution system on tariff rates?

Roughly outlined, the method and answer are as follows: A logical way to make the necessary differentiation would be to modify either the charges against the occupancy hazards for each building classification, the deficiency charges or credits, or the exposure charges. It was with this point in view that there was finally adopted, so that equitable fire insurance rates might be arrived at, a tariff book for California consisting of some six or more sections. Each section has practically the same alphabetically listed occupancies, but in many cases with varying charges. Not only may the occupancy charges be found to vary, but also the building deficiency charges and credits, as well as the exposure charges. Having these varied sections, towns when classified, may easily be placed in the proper section. With a continuation of the refining process, the basic occupancy charges, their exposure charges or any combination are varied by percentage deductions or additions to the various sections.

By the above system (each and every town having been properly classified according to its deficiencies, these deficiencies varying by one point only, and ranging from fifteen upward, the derivation of which I shall explain later) all towns may be designated to a certain section together with the percentage modifications of sections should same be applicable. To tie this method to the topic in discussion we will assume that, on account of deficiencies existing in the water features of a town, their fire department, and other miscellaneous considerations, the number of deficiency points allotted to the town was 39. Of this 39, we will assume that 13 of them are composed of deficiencies within the water system proper.

Now with the 39 points of deficiencies, the building occupancies of that town will fall under a certain section, the basic charge for a drug store in that section will be for:

| | |
|---|---|
| Class B | 160 per hundred |
| Class C | 190 per hundred |
| Class D | 250 per hundred |

The building deficiency and exposure charges are added to this for final rate. We will now assume that this town makes enough changes within its water distribution system to eliminate the 13 points. The deficiency points of the town now total 26 and being fewer should enjoy a differentiation in the rate. Hence with 26 points, the town is placed under another section and it happens that the basic charge on the same drug store becomes for:

| | |
|---|---|
| Class B | 150 per hundred |
| Class C | 180 per hundred |
| Class D | 225 per hundred |

In this, as well as in the previous case, buildings' deficiencies and exposures are added to get the final rate, modifications in proportionate degree being applied. Hence it is possible that, as cities improve their water distribution system, very often with little additional expense, enough may be dropped from their deficiency point allotment to affect materially fire insurance rates.

Practically all of the foregoing discussion has referred to the tariff rates. We will now enter upon the question of specific rates, the rates usually formed from some modification of the tariff or by application of special schedules.

For example, in the rating of certain frame buildings, there are cases where modification of tariff rates furnish specific rates. It happens that, in certain classes of risks, the size of main together with hydrant would reduce the basic rate on a building of that class, if within certain limiting distance from the hydrant and main. There are numerous schedules in use, and in order to simplify matters as much as possible, I shall employ a schedule which is most commonly used, its application being to A, B and C class buildings, of ordinary occupancy.

The starting point or key rate for any final rate on a building depends on several factors, namely, the basis rate, the city's deficiency points, as before, and classification of the building. The basis rate is uniform for all cities, as it is the computed cost per hundred necessary to conduct business. To this fixed basis is added each particular city's or town's deficiencies. The summation of the two forms a city's rate, which is fixed. To obtain the key rate for a building, as to class, a certain fixed percentage of the above summation is taken, this percentage decreasing in order from class C to class A construction. The total summation gives us a key rate for buildings of class A, B, or C in that town. As an example, assume that:

| | *cents* |
|---|---|
| Basis rate is | 25 |
| City's deficiency points | 30 |
| The city's rate is | 55 |

A diminishing percentage of this, and added to it, gives the key rate, on all buildings varying from class C to class A. The final

rate would be ended here, if all buildings of the same class had the same occupancy, with absolutely the same internal deficiencies and no exposures. Hence, in order that each building of a given class may have an equitable rate, each building's deficiencies, i.e., open elevator shafts, open stairways, inferior wall construction; in short, some 40 odd deficiency charges, if such exist, are assigned against the building in question, these usually being in a percentage of the key rate. These charges added to the key rate of the town or city, together with charges corresponding to the occupancy hazard involved, give a final building rate.

The fixed basis is not a variant. The classification of buildings have been taken care of by a diminishing percentage charge in the order from class C to class A construction. Each building has its own particular deficiencies and occupancy, hence there is but one remaining factor, the deficiency points of the town or city under consideration. Assuming that the city's deficiency points amount to 30 in all, part of those points were due to a poor water supply, with numerous poorly laid mains not well gridironed, or the town had outgrown the old water system, in general, the mains being too small, dead ended, etc., and then the town in question lays proper mains, improves its storage capacity, etc., with the result that five (assumed) of the deficiency points against the city are removed. The city's deficiency points drop from 30 to 25 and the city rate becomes 25 + 25, or 50 instead of 55. The key rate of buildings are correspondingly lowered and consequently all rated buildings participate in a rate reduction.

Up to now, I have purposely ignored the methods of preparing deficiency charges, to lay greater emphasis on rate making and the possible effect on those rates of a distribution system.

I shall now endeavor to explain of what those charges consist and their relations to towns and cities, not by means of too much detail, but by utilizing points here and there merely to illustrate the deficiency charges which might possibly be made should those conditions be present. Incidentally I am assuming that the distribution system constitutes everything from the storage to the hydrant outlet. The bureau with which I am affiliated has utilized for many years a system of computing deficiency points based on the following features: (1) Water works, which is divided into some thirteen subdivisions, each with its proper charge. (2) Fire department, similarly divided into thirteen subdivisions, each with its

corresponding charge or charges. (3) General considerations, consisting of twelve subdivisions each with a charge. It may be well to state here that these general considerations take into account such things as police system, streets, conflagration hazard, climatic conditions, previous fire record and similar features. Deficiencies under these three heads, on addition, give the city's or town's deficiency points, which was previously mentioned in the methods of rate making. Of the foregoing the water works deficiency points may run in good conditions from a minimum of 7 to 9 to a higher number depending on the water system.

Subsequent to the initial adoption and utilization of the above schedule, however, there was issued by the National Board of Fire Underwriters, the "Standard Schedule for Grading Cities and Towns of the United States with Reference to Their Fire Defenses and Physical Conditions." This schedule has been adopted by us. The ratio between the two schedules is 1:110. This Standard Grading Schedule is very elastic, in that very small deficiency charges and corresponding credits may be taken into consideration. In all the total number of points of deficiency total 5000 and are divided into the following divisions and relative values:

| | *points* |
|---|---|
| Water Supply | 1,700 |
| Fire Department | 1,500 |
| Fire Alarm | 550 |
| Police | 50 |
| Building Laws | 200 |
| Hazards | 300 |
| Structural Conditions | 700 |
| Total | 5,000 |

From this point on, I shall quote more or less directly from the schedule.

Climatic conditions affect fire losses, by reason of the frequency of fires due to the heating hazard, by retarding the response of fire apparatus, by hampering effective fire fighting during cold weather and storms, by the increase in combustibility due to hot dry weather, and by the greater probability of fires spreading at times of high winds. Also that earthquakes, tornadoes, hurricanes, cyclones, blizzards, floods and other unusual conditions have an influence on the conflagration hazard. These elements are to a more or less degree common to the whole county, and therefore no deficiency is considered in the schedule for normal climatic conditions.

To cover these abnormal conditions, as those just quoted, the originators of the schedule have called these features super-deficiencies and as such have given them chargeable points which are as a rule added, should they exist, to the chargeable points in the schedule proper.

To illustrate more fully, we will take the problem of hot dry weather. In a given town, the deficiency points are represented by the following empirical formula

$$\frac{mt^2}{150d}$$

where $m$ = average number of months per year
$t$ = average monthly mean maximum temperature
$d$ = average number of days per month with 0.01 inches precipitation

The schedule advocates the application of the above to towns which have months having an average mean maximum temperature of 65 degrees or more with six or less days of 0.01 inch or over of rain fall, i.e.,

| | |
|---|---|
| Average number of months per year | 5 |
| Average monthly mean temperature | 80 |
| Average number of days per month with 0.01 inch rainfall or greater | 4 |

Then super-deficiency point for dryness $= \frac{5 \times 6400}{150 \times 4}$ or about 53 points.

This charge has several modifications, locality and judgment controlling its proper usage. As to the normal deficiencies of a town or city totaling 5000 points, I will devote the rest of this paper to the 1700 points which are allotted to the water supply. Before entering on this, I want to clear the point as to a town's or city's classification. A first class city or town is one receiving 0 to 500 deficiency points, then on up to ninth class, varying each class by 500 points, the ninth class being one which receives 4001 to 4500 points. A tenth class city or town is one receiving more than 4500 points, or without a water supply and having a fire department grading tenth class, or with no fire protection.

The water supply charges are made under 32 separate items or deficiencies, these charges are made in cases by definite points, in others by points corresponding to the per cent of deficiency. This scale is given as follows:

*Deficiency scale*

| | 0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0% | 0 | 10 | 25 | 45 | 67 | 90 | 112 | 134 | 156 | 178 | 200 |
| 1% | 1 | 12 | 27 | 47 | 70 | 92 | 114 | 136 | 158 | 180 | |
| 2% | 2 | 13 | 29 | 50 | 72 | 94 | 116 | 138 | 160 | 182 | |
| 3% | 3 | 15 | 31 | 52 | 74 | 97 | 119 | 141 | 163 | 185 | |
| 4% | 4 | 16 | 33 | 54 | 77 | 99 | 121 | 143 | 165 | 187 | Points |
| 5% | 5 | 18 | 35 | 57 | 79 | 101 | 123 | 145 | 167 | 189 | |
| 6% | 6 | 19 | 37 | 59 | 81 | 103 | 125 | 147 | 169 | 191 | |
| 7% | 7 | 21 | 39 | 61 | 83 | 105 | 127 | 149 | 171 | 194 | |
| 8% | 8 | 22 | 41 | 63 | 85 | 108 | 130 | 152 | 174 | 196 | |
| 9% | 9 | 24 | 43 | 65 | 88 | 110 | 132 | 154 | 176 | 198 | |

It will be found that there is a lesser increment on the scale for the first 30 per cent than for the remainder. Quoting from the schedule:

a deficiency of 10 per cent in good or moderately good conditions has less actual effect, than where conditions are poor. In using the scale either a fractional, full or multiple portion is used depending on item under consideration. Where quantities or numbers are not available, the degree of deficiency is usually classified as follows: Slight = 10 per cent, moderate = 25 per cent, considerable = 50 per cent, serious = 75 per cent and total = 100 per cent. Utilization of these classifications require judgment, since that which would be serious in a large city would only be moderate or considerable in a small one due to the infrequency of fires.

*Water supply.* From a standpoint of fire protection, a gravity system, one which delivers water directly to hydrants without the aid of pumps is considered ideal. However, the excellent pumping equipment of some cities, so nearly approaches the gravity system in reliability and performance that in the schedule no distinction is made in the two types.

To quote further from the schedule:

Reliable fire protection requires such duplication of all parts of a water system, that with such parts out of service as may reasonably be expected to be inoperative, the system will still be able to furnish the required fire flow.

It has been assumed that a storage sufficient to supply ten hours fire flow during a period of five days of maximum consumption is sufficient to permit the making of repairs, alterations and additions to a water supply system.

Where storage fluctuates 10 per cent in 24 hours, the minimum maintained storage is used in calculations, and should the storage

not be sufficiently elevated and fire engines are not used, the top 25 feet in standpipes can only be considered as storage. Supplies from outside sources are given credit, the amount depending on the good and bad points involved. Two such emergency systems can be considered (*1*) those under same management; (*2*) those under outside control and management. The deficiency of a primary source or system can be offset in whole or in part for any item by the added protection of a secondary source or system. This, however, cannot be applied to fire boats where the same would deliver water through pipe lines which are drained part of the year. Where a water system is utilized and cisterns and the like make suction available, the same can be utilized to offset certain points. No credit is given for above cisterns, etc., should water system not exist. They are then taken into account under Fire Department.

The schedule further states

> that requirements given hereinafter are based in part upon the assumption that the maximum daily consumption is 50 per cent in excess of the average, but in all cases of application the actual average consumption for the year previous shall be taken as the average consumption and the maximum consumption for any twenty-four hours in the past three years taken as the maximum consumption, unless conditions have so changed that this maximum will not occur again.

Fire flow is based upon population, given by the empirical formula $G=1020\sqrt{P}\ (1-0.01)\sqrt{P}$. Where $G$ represents gallons per minute, $P$ population in thousands, the final determination of which is affected by structural conditions and fire department. Ratio of engine capacity to fire flow is 2 to 3.

As to adequacy of water, two features are considered.

1. Ability to deliver fire flow at any pressure down to 20 pounds, except that a minimum of 10 pounds is permissible in high value districts having no deficiency in hydrant distribution, and having no deficiency in hydrant specifications, each hydrant being supplied with a steamer connection. This is considered a measure of the capacity of the system to maintain supply under conditions of conflagration, with the system in full operation. With this as a basis, available flow at 20 and 10 pounds determines deficiency under adequacy of supply.

2. The second feature determining adequacy is the ability of the system to deliver fire flow or part thereof at pressures which permit direct hose usage. For high value districts, this pressure should be

around 75 pounds, or more, depending on static available, heights of structures and engine capacity available in closely built residential districts and in districts where there are not more than ten buildings which exceed three stories in height. The allowable pressure is sixty pounds. This can be reduced to fifty pounds in rural mercantile districts where buildings do not exceed two stories in height and in sparsely settled residential sections.

Two-thirds the fire flow at these pressures may offset in whole or part any deficiency in the engine capacity. To illustrate the 32 charges and subcharges composed of some 1700 points, I will take them in the order that they are usually made.[3]

[3] The remainder of the paper is not reproduced here, since it contains verbatim quotations from the printed "Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions." The Schedule is obtainable in complete form from the National Board of Fire Underwriters, New York City.—*Editor*.

# MIXING DEVICES AND REACTION TIME[1]

By Charles P. Hoover[2]

Mr. J. W. Ellms, in reporting on the results of Experiments on the Purification of the Water Supply of Milwaukee, says that, in the treatment of the Lake Michigan water, quick mixing of the chemical with the water is the object sought, and that long mixing appeared to be unnecessary and even harmful in breaking up the floc, and in order to obtain quick diffusion of the chemicals with the water, he used several types of devices, which are described in detail in his report: the fish ladder, the fall, the flume, and finally the hydraulic jump. Mr. Ellms points out that all chemical reactions of the types used in coagulation of water are extremely rapid, their velocity increasing with increasing temperature, so that it becomes a matter of bringing together as quickly as possible the reacting compounds.

On the other hand, the results of Mr. Wilfred F. Langelier's experiments at Sacramento, California,[3] indicate that prolonged agitation is not objectionable, but desirable, and, in the treatment of the turbid Sacramento River water, that it was necessary that the precipitate of aluminum hydroxide be kept in suspension until it has had sufficient opportunity to gather together into clusters a maximum number of the fine particles which give the water its turbidity, and which it is desired to remove. He believes that many existing filter plants are provided with inadequate mixing devices and that in such instances more adequate mixing would result in greater efficiency and economy of operation.

Consideration must be given the fact that these men were working on entirely different water supplies, one being a turbid river water, and the other a reasonably clear lake water; so it is probable that both arrived at the right conclusion as to the best method for treating the particular water on which they were working.

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 25, 1923.

[2] Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio.

[3] Engineering News-Record, June 2, page 924, 1921.

## PLANT RESULTS AT COLUMBUS AND DEFIANCE

A mixing period of one hour and fifteen minutes, with a velocity of 0.30 foot per second through the mixing tanks at the Columbus plant is not adequate to effect maximum coagulation of muddy Scioto River water, the turbidity of which is in a fine state of suspension. If, for example, samples of water, during the muddy water season, are collected at the outlet of the mixing tanks at the Columbus plant and given additional agitation, say for fifteen or thirty minutes, at a velocity of 0.6 foot per second, an improved floc is obtained, which settles quickly and leaves a much clearer supernatant than settled portions direct from the plant mixing tanks.

*Effect of more vigorous agitation than received in the mixing basins at the Columbus plant*

| DATE (MAY, 1923) | ALUM ADDED | TURBIDITY OF RIVER WATER | WATER PASSED THROUGH MIXING TANKS, ALLOWED TO SETTLE 30 MINUTES TURBIDITY OF SUPERNATANT | WATER PASSED THROUGH MIXING TANKS, AGITATED 30 MINUTES AT 0.6 FOOT PER SECOND. ALLOWED TO SETTLE 30 MINUTES. TURBIDITY OF SUPERNATANT |
|---|---|---|---|---|
| | *grains per gallon* | | | |
| 15 | 9 | 600 | 55 | 15 |
| 18 | 7 | 270 | 55 | 10 |
| 19 | 5 | 160 | 20 | 2 |
| Average.. | 7 | 343 | 43 | 9 |

Mr. H. T. Campion, Superintendent of Water Works at Defiance, Ohio, calls attention to the fact[4] that, under ordinary operating conditions at the water softening plant at Defiance, the water leaving the carbonation chambers has at all times a better and more distinct floc than the water entering, and he says that this may be due to the additional agitation caused by blowing the $CO_2$ gas into the water, or, as an alternate explanation, he says there may be some unsolved reactions taking place, which improve the floc. The writer has seen the secondary floc in the carbonation chambers at defiance, and is of the opinion that it is due to the additional agitation.

[4] Second Annual Report of Ohio Conference on Water Purification, page 133, 1922.

## LABORATORY AGITATION EXPERIMENTS AT COLUMBUS

Experiments were made at Columbus, to determine:

1. Velocities required to keep the precipitated chemicals in suspension.
2. The effects of short and long periods of mixing and agitation.

These experiments were made on turbid water with aluminum sulphate only, and on hard water, using lime, soda-ash and alum in its treatment.

The equipment used in the experiments consisted of three agitating units, the speed of rotation and size of paddles of which could be regulated or easily changed. The paddles revolved in glass jars, 6 inches in diameter and 9 inches deep, and, in order that constant or desired temperature could be maintained in the water under treatment, each of these jars was slipped inside a larger jar, provided with an inlet water pipe at the bottom and an outlet pipe at the top, so as to permit the circulation of water of the desired temperature around the jars.

## RESULTS OBTAINED BY AGITATION IN TREATMENT OF TURBID WATER

It has already been pointed out that a period of one hour and fifteen minutes with a velocity of 0.3 foot per second through the mixing tanks at the Columbus plant is not adequate to effect maximum coagulation of turbid water. A number of experiments were therefore made in the experimental plant to determine the effect on coagulation with velocities of 0.13 foot per second, 0.22 foot per second and 0.60 foot per second, the agitation period being thirty minutes, and also by bringing together, as quickly as possible, the coagulant and the water by vigorous shaking for thirty seconds. All of the samples were allowed to stand twenty minutes, after which the supernatant was poured off and the turbidity was determined. In all cases the results were better in samples agitated at the higher velocities, and it was possible to get better results on water having a turbidity of 325 parts per million with 2 grains of alum with a velocity of 0.60 foot per second than with 4 grains at a velocity of 0.13 foot per second, and to get as good results with 2 grains at 0.6 foot per second as with 4 grains at 0.22 foot per second. River water, having a turbidity of 325 parts per million, and treated with

4 grains of alum, agitated for 20 minutes and allowed to settle twenty minutes, showed the following results at different velocities.

*Effects of agitation at varying velocities*

| SAMPLE NUMBER | VELOCITY | TIME OF AGITATION | TIME OF SEDIMENTATION | TURBIDITY |
|---|---|---|---|---|
| | *foot per second* | | | *p.p.m.* |
| 1 | None | | | 325 |
| 2 | Vigorous | 30 seconds | 30 minutes | * |
| 3 | 0.13 | 30 minutes | 30 minutes | 90 |
| 4 | 0.22 | 30 minutes | 30 minutes | 30 |
| 5 | 0.60 | 30 minutes | 30 minutes | 2 |

* Not determined, but not noticeably different from no. 1.

These results were demonstrated several times, once for Mr. Waring, Assistant Engineer of the Ohio State Department of Health, once for Mr. A. E. Kimberly, Consulting Engineer, Columbus, Ohio, and for the assistant chemists at the Columbus plant, Messrs. Melick, Meckstroth and Kaiser.

Coagulation results attained on Columbus water at velocities of 0.6 per second can be approached only, time and temperature being the same, if quick mixing, or, low velocities are used by adding an excess quantity of alum, as indicated below.

*Effect of one hour agitation at velocities of 0.6 foot per second and short, vigorous agitation on turbid Scioto River water*

| TURBIDITY OF RIVER WATER | TURBIDITY RESULTS, OBTAINED BY AN AGITATION PERIOD OF | | ALUM USED |
|---|---|---|---|
| | Thirty seconds | One hour | |
| *p.p.m.* | *p.p.m.* | *p.p.m.* | *grains per gallon* |
| 575 | 500 | 380 | 2 |
| 575 | 150 | 10 | 4 |
| 575 | 50 | 3 | 6 |
| 575 | 25 | 1 | 8 |

The results obtained in experiments to determine just how long the agitation period should be were not very consistent, temperature and nature of the water treated being important factors. Therefore, the author does not wish at this time to recommend any definite agitation time, but prefers to wait in order to make many

more experiments before attempting to do so. A general impression, however, gathered from the results of our experiments, indicates that the period for turbid water, like that of the Scioto River, at 16°C., is between twenty and thirty minutes. See the following table, showing the average results of two experiments. River water, having a turbidity of 300 parts per million was treated with 4 grains of alum, and agitated for periods of from thirty seconds to one hour.

*Effect of varying time of agitation*

| SAMPLE NUMBER | PERIOD OF AGITATION | VELOCITY OF AGITATION | TURBIDITY | TEMPERATURE |
|---|---|---|---|---|
| | | *foot per second* | *p.p.m.* | *°C.* |
| 1 | 30 seconds | Vigorously shaken | 130 | 16 |
| 2 | 5 minutes | 0.60 | 80 | 16 |
| 3 | 10 minutes | 0.60 | 50 | 16 |
| 4 | 20 minutes | 0.60 | 20 | 16 |
| 5 | 30 minutes | 0.60 | 18 | 16 |
| 6 | 45 minutes | 0.60 | 18 | 16 |
| 7 | 60 minutes | 0.60 | 14 | 16 |

## RESULTS OBTAINED BY AGITATION ON WATER SOFTENING

Samples of clear, hard, Scioto River water, treated with 8 grains per gallon of lime, 5 grains per gallon of soda-ash, and 1 grain per gallon of aluminum sulphate were agitated at 0.13, 0.22 and 0.60 foot per second and allowed to settle twenty minutes, after which they showed the following turbidities.

*Effects of agitation at varying velocities on softened water*

| SAMPLE NUMBER | TIME OF AGITATION | VELOCITY | SEDIMENTATION TIME | TURBIDITY |
|---|---|---|---|---|
| | *minutes* | *foot per second* | *minutes* | *p.p.m.* |
| 1 | 1 | Vigorously | 10 | 200 |
| 2 | 20 | 0.13 | 10 | 115 |
| 3 | 20 | 0.22 | 10 | 105 |
| 4 | 20 | 0.60 | 10 | 30 |

Samples agitated at 0.13 foot per second showed a large amount of floc to be settled to the bottom of the container. Samples agitated at 0.22 foot per second showed floc settled toward the

bottom, but not deposited, whereas, at a velocity of 0.60 foot per second, the floc was evenly distributed, none settling out. Results at Columbus indicate that the velocity must be more than 0.30 foot per second, but need not be more than 0.60 foot per second to keep the precipitated chemicals in suspension.

Twenty nine samples of river water were treated with lime, soda-ash and alum and agitated for periods ranging from thirty minutes to twenty-four hours, but the temperature factor was not controlled or maintained constant. The results obtained in this series of tests are shown in the following table.

*Effects of prolonged agitation on water softening reactions*

| SAMPLE NUMBER | PERIOD OF AGITATION | TOTAL HARDNESS | REACTION OBTAINED* |
|---|---|---|---|
| | *hours* | *p.p.m.* | *per cent* |
| 1 | 0.5 | 103 | 87 |
| 2 | 1 | 103 | 87 |
| 3 | 2 | 89 | 91 |
| 4 | 4 | 79 | 94 |
| 5 | 8 | 71 | 96 |
| 6 | 16 | 59 | 100 |
| 7 | 24 | 66 | 98 |

Note: Hardness of the raw water was 399 parts per million. 13 grains per gallon of lime, 9.5 grains per gallon of soda-ash, and 0.5 grains per gallon of alum were added. Temperature averaged 23°C.

* Assuming complete reaction at 16 hours.

The results show that the hardness was reduced from 399 parts per million to 59 parts per million, the lowest result was obtained after sixteen hours agitation and that 87 per cent of the reaction accomplished took place in the first thirty minutes.

Whether this reduction in hardness was due to the continuous agitation or simply to the time which was allowed for reaction became the question to be determined, so the experiments were repeated and unagitated samples were run as blanks. The average results of these experiments are shown in the next two tables, one set of samples treated at a temperature of 22°C., and the other at 15°C.

*Effects of prolonged agitation and time on water softening reactions*

Averages of duplicate experiments

| CONTINUOUS AGITATION | | BLANK WITH SHORT AGITATION + REACTION TIME | | |
|---|---|---|---|---|
| Period of agitation | Reaction accomplished | Period of agitation | Reaction time | Reaction accomplished* |
| Temperatures averaging 22°C. | | | | |
| *hours* | *per cent* | *minutes* | *hours* | *per cent* |
| 0.5 | 91 | 30 | 0.5 | 89 |
| 1 | 93 | 30 | 1 | 92 |
| 2 | 95 | 30 | 2 | 97 |
| 4 | 97 | 30 | 4 | 96 |
| 8 | 100 | 30 | 8 | 100 |
| Temperatures averaging 15°C. | | | | |
| 0.5 | 72 | 30 | 0.5 | 72 |
| 1 | 78 | 30 | 1 | 78 |
| 2 | 82 | 30 | 2 | 82 |
| 4 | 85 | 30 | 4 | 85 |
| 8 | 91 | 30 | 8 | 91 |
| 16 | 100 | 30 | 16 | 100 |

*Assuming complete reaction in 8 hours at 22°C. and in 16 hours at 15°C.

The results of these experiments indicate that prolonged agitation is not necessary, for at 22°C., 89 per cent of the reaction accomplished took place in the first thirty minutes agitation period, and at 15°C. 72 per cent of the reaction took place in thirty minutes, and that the balance of the reaction that was accomplished was obtained as effectually by simply allowing reaction time as by continuous agitation. These results are also duplicated in plant operation.

Eighty-nine per cent of the reaction accomplished at the Columbus plant takes place in the mixing tanks, one and one-half to two hours. Four per cent takes place in the fifteen hours through the settling basins and seven per cent in passing through the filters. These are the results of 16,000 tests over a period of fifteen years. The hardness of the river water, the hardness of the water at the entrance to and outlet from settling basins and the effluent from the filters is shown below.

*Average hardness*

| | p.p.m. |
|---|---|
| River water | 271 |
| Water at entrance to settling basins | 117 |
| Water at outlet of settling basins | 110 |
| Filtered water | 98 |

The percent of reaction accomplished through the mixing basins in different months of the year are shown in the next table.

*Hardness removed in the mixing tanks*

| | per cent |
|---|---|
| 1908 to 1923, December, January, February | 87 |
| 1908 to 1923, March, April, May | 87 |
| 1908 to 1923, June, July, August | 91 |
| 1908 to 1923, September, October, November | 90 |

These figures are rather startling, because they indicate that large settling basins are not so necessary for water softening as has been supposed, although, Mr. Wm. R. Copeland, formerly Chemist in Charge of the Columbus Water Softening and Purification Works, now with the Milwaukee Sewerage Commission, has pointed out that large settling basins are of advantage in that they serve as equalizers in case of over- or under-treatment of water.

## AGITATING DEVICES

The types of mixing devices used in water purification plants, are, briefly, baffled tanks, with various combinations, the combination of baffles and orifices, tanks provided with rotating paddles or propellers, or a combination of two propellers, wherein one propeller rotates in one direction and one in the opposite direction. This latter type gives very vigorous agitation. Another type of mixing device that is soon to be tried out at Columbus is the Dorr agitator, which consists of a suitable tank, containing a slowly revolving mechanism, which allows the coagulated particles to settle to the bottom where they are scraped to the center and, by means of an air lift, elevated through a hollow, vertical, central shaft, and distributed evenly over the surface, whereby a continuous, evenly distributed circulation is kept up and motion is maintained within the mass, and not only near the bottom and sides, as is the case with tanks provided with insufficient rotating paddles, or paddles operated at too low speed.

Great developments have been made in rotating paddle agitators as a result of experiments in connection with the design of the Sacramento filtration plant under the direction of Mr. Charles Gilman Hyde. Mr. Harry N. Jenks, who was connected with these experiments, has told me that, in order to get a uniform velocity throughout the entire agitating tank, it was necessary to have the area of the paddles 25 per cent of the area of the vertical cross section, and, with this ratio, 0.6 of a foot velocity can be maintained in the coagulation tanks at Sacramento by having the paddles make one rotation in three minutes.

The paddles in the agitating tanks at the Sacramento plant are swung from the paddle arms by means of plate clamps, the paddles thus being allowed to assume a more or less horizontal position when the agitating device is started, but the weight of the paddles is such that, when motion in the tanks is attained, the paddles assume a vertical position. This is to take the load off of the motor in starting up the agitators.

If the proper relation of the area of the paddles to the area of the central vertical section of the tank is 25 per cent, then the speed of rotation required to get any velocity wanted is easily calculated.

The advantages of mechanical agitators over the usual baffled mixing tanks are as follows:

1. They are probably less expensive to construct.

2. For a single mixing tank a more compact arrangement is possible, and therefore can be more readily housed or covered.

3. They remove the necessity of lifting the water the extra two or three feet necessary to pass water through baffled mixing tanks, and, although agitators require power to keep them running, the cost of operation, if a proper drive is provided, should be less than the cost of the additional lift of the water.

4. They provide greater flexibility. Most plants are built in the beginning with over-capacity, and the plant is usually designed to get the desired velocity at the full capacity of the plant; consequently, less velocities are attained when the plant is operated at rates lower than the maximum, whereas with the mechanical agitators, additional paddles may be easily added, or paddles removed, or the speed of rotation may be easily changed, and the velocities desired, easily obtained.

5. They provide greater accessibility.

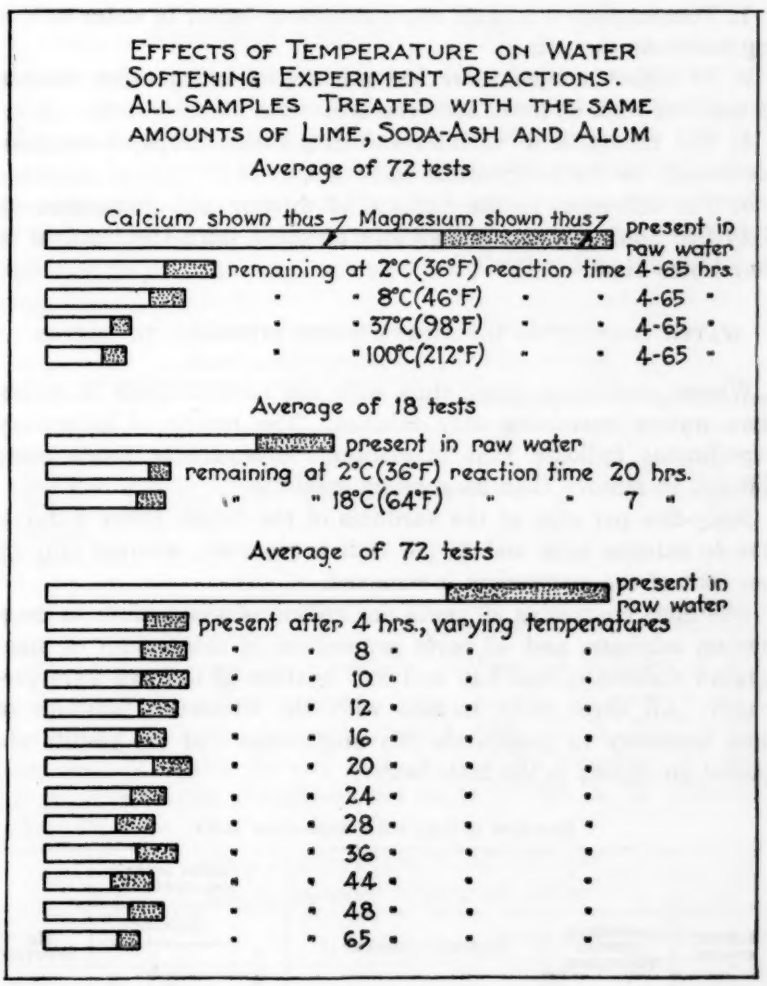
EFFECTS OF TEMPERATURE ON WATER SOFTENING EXPERIMENT REACTIONS. ALL SAMPLES TREATED WITH THE SAME AMOUNTS OF LIME, SODA-ASH AND ALUM
Average of 72 tests
Calcium shown thus Magnesium shown thus
present in raw water
remaining at 2°C(36°F) reaction time 4-65 hrs.
8°C(46°F) 4-65
37°C(98°F) 4-65
100°C(212°F) 4-65
Average of 18 tests
present in raw water
remaining at 2°C(36°F) reaction time 20 hrs.
18°C(64°F) 7
Average of 72 tests
present in raw water
present after 4 hrs., varying temperatures
8
10
12
16
20
24
28
36
44
48
65

FIG. 1

## REACTION TIME

The data in figure 1 show that

1. Temperature is a much more important factor in water softening reactions than time.
2. At higher temperatures less calcium and magnesium remain in solution than at lower temperatures.
3. The reduction of calcium and magnesium drops almost proportionally as the temperature increases.
4. The difference in the removal of calcium and magnesium in sixty-five hours time is not greatly different from the removal in four hours time.

## WATER CONTAINING MAGNESIUM SALTS DIFFICULT TO SOFTEN

Waters containing magnesium salts are more difficult to soften than waters containing only calcium. The results of laboratory experiments indicate that magnesium carbonate is much more difficult to remove than magnesium sulphate.

Sixty-five per cent of the hardness of the Scioto River water is due to calcium salts and 71 per cent is removed, whereas only 52 per cent of the magnesium is removed.

Solutions containing 39 parts per million of magnesium as magnesium sulphate, and 43 parts per million of magnesium as magnesium carbonate, and half and half mixture of the two were prepared. All three were treated with the theoretical amount of lime necessary to precipitate the magnesium and the results obtained are shown in the table below:

*Reaction of lime with magnesium salts*

| SAMPLE NUMBER | MAGNESIUM BEFORE TREATMENT | MAGNESIUM PRESENT AS | ANALYSIS AFTER TREATMENT | | | | Mg REMOVED |
|---|---|---|---|---|---|---|---|
| | | | Magnesium | Alkalinity | | | |
| | | | | Totol | Phenol-phthalein | Caustic | |
| | *p.p.m.* | | | | | | *per cent* |
| 1 | 43 | $MgCO_3$ | 39 | 190 | 79 | 0 | 9 |
| 2 | 39 | $MgSO_4$ | 10 | 36 | 23 | 10 | 74 |
| 3 | 41 | $MgCO_3$ and $MgSO_4$ | 26 | 76 | 45 | 14 | 37 |

It will be noticed that 74 per cent of the magnesium as magnesium sulphate was removed, whereas only 9 per cent of the magnesium as magnesium carbonate was removed.

### MAGNESIUM REDUCED BY OVERTREATMENT

In order to reduce the hardness of water high in magnesium salts to the lowest possible degree, it is necessary to use an excess amount of lime, then neutralize the excess lime with soda-ash, this is in addition to amount necessary to combine with permanent hardness leaving residual or excess sodium hydroxide in the treated water.

The following are the results of analyses of samples of raw and softened water from the Buckeye Steel Casting Company, Columbus, Ohio.

*Effects of overtreatment on softened water*

Results are expressed in parts per million

| | RAW WATER | SOFTENED WATER |
|---|---|---|
| Alkalinity (total) | 337 | 92 |
| Alkalinity to phenolphthalein | 0 | 70 |
| Alkalinity (caustic) | 0 | 48 |
| Calcium | 161 | 6 |
| Magnesium | 43 | 3 |
| Total hardness | 579 | 27 |
| Total hardness (grains per gallon) | 34 | Less than 2 |

The following are the results of analyses of samples of water from the water softening plant of the Chicago, Milwaukee and St. Paul Ry., at Scotland, South Dakota. Mr. C. H. Koyl is Chief Engineer of Water Service and Mr. J. S. Eastman in charge of plant operation. Analysis was made by Mr. A. A. Chambers, Chief Chemist.

*Effects of overtreatment on softened water*

Results expressed in parts per million

| | RAW WATER | SOFTENED WATER |
|---|---|---|
| Calcium | 225 | 7 |
| Magnesium | 126 | 2 |
| Total hardness | 1080 | 26 |
| Total hardness (grains per gallon) | 63 | Less than 2 |

These results show that it is possible to reduce, by excess treatment, hardness from 579 to 1080 parts per million to less than 30 parts per million (less than 2 grains per gallon).

The results of our experiments indicate that it is impossible to reduce the hardness of water containing a large amount of magnesium carbonate to a low figure unless excess lime is used, for by treating water containing magnesium carbonate with just sufficient lime to combine with it, the magnesium is reduced only 30 per cent and the alkalinity is reduced less than 1 per cent, indicating that the lime simply combines with the carbonates to form a basic carbonate. By adding 2 grains per gallon excess lime, the alkalinity is reduced 70 and the magnesium 88 per cent, respectively.

### SPLIT TREATMENT

When it is not desirable to have excess sodium hydroxide in the treated water, then, in order to reduce the hardness to as low a figure as possible, split treatment should be used, that is, treat as large a portion of the hard water as possible to get maximum reduction of hardness, then neutralize the excess sodium hydroxide by raw water. The proper proportion may be ascertained only by knowing the analysis of the water to be softened. The following tables show what may be accomplished by split treatment.

*Effects of split treatment*

| | Hardness p.p.m. |
|---|---|
| Raw water | 333 |
| 25 per cent receiving all chemicals and neutralized with 75 per cent raw water | 79 |
| 50 per cent receiving all chemicals and neutralized with 50 per cent raw water | 79 |
| 75 per cent receiving all chemicals and neutralized with 25 per cent raw water | 100 |
| 90 per cent receiving all chemicals and neutralized with 10 per cent raw water | 156 |
| Raw water | 305 |
| 25 per cent receiving all chemicals and neutralized with 75 per cent raw water | 96 |
| 100 per cent receiving all chemicals | 133 |
| Raw water | 329 |
| 25 per cent receiving all chemicals and neutralized with 75 per cent raw water | 126 |
| 50 per cent receiving all chemicals and neutralized with 50 per cent raw water | 114 |
| 75 per cent receiving all chemicals and neutralized with 25 per cent raw water | 99 |
| 100 per cent receiving all chemicals | 145 |

The tables show that, by proper split treatment, the hardness was reduced 72, as against 55, per cent for the straight treatment.

## CONCLUSIONS

1. Results of plant operation and laboratory experiments indicate that velocities of 0.3 foot per second do not provide sufficient agitation for the treatment of turbid water or for water softening, but that the velocity does not need to exceed 0.6 foot per second.
2. Coagulation results obtained on turbid water at velocities of 0.6 foot per second may be obtained at lower velocities only by adding an excess amount of coagulant.
3. A short mixing period of twenty or thirty minutes at 0.6 foot per second velocity is more effective than a mixing period of one and one-half hours at 0.3 foot per second velocity.
4. Mechanical agitators are less expensive to build, more compact obviate the necessity of lifting the water the extra two or three feet necessary to pass through baffled mixing tanks and provide greater flexibility and accessibility.
5. Temperature is a more important factor in water softening than time.
6. Waters containing magnesium salts are more difficult to soften than waters containing only calcium, magnesium carbonate being especially hard to remove.
7. Magnesium salts may be precipitated by overtreatment with lime.
8. By overtreatment with lime, then neutralizing the excess lime with sodium carbonate, waters having a hardness of 572 to 1044 parts per million may be reduced to a hardness of less than 30 parts per million, or less than 2 grains per gallon.
9. If it is not desirable to use excess treatment, better water softening results are obtained by split treatment than by the ordinary method of applying all of the chemicals to all the water under treatment.

## *DISCUSSION*

WILFRED F. LANGELIER:[5] The writer is interested to note that Mr. Hoover's observations with regard to the most effective and

[5] Associate Professor of Sanitary Engineering, University of California, Berkeley, Calif.

economical coagulation of Scioto River water with alum confirm in most important details the results of our studies conducted in the Sanitary Engineering Laboratory of the University of California, and later at Sacramento, as published in the writer's paper in 1922, to which Mr. Hoover has made reference.

Mr. Hoover finds that coagulation was most effective with vigorous initial agitation, followed by a twenty- to thirty-minute period of mixing, at a velocity of approximately 0.6 foot per second. This compares with our conclusions, which were stated as follows: "The initial velocity should be fairly high, say 2.0 feet per second. In each succeeding tank the velocity should be reduced gradually until in the last tank the minimum velocity shall be just sufficient to keep the floc in suspension" also "an actual mixing period of twenty to thirty minutes is somewhat more than ample, but on account of short-circuiting (which must occur in any type of continuous-flow basin) provision should be made for a somewhat longer theoretical retention period, say forty minutes."

In attempting to explain the divergent conclusions obtained by Mr. Ellms with lake water at Milwaukee and those obtained with the Sacramento River water, reference is made to the dissimilar character, particularly with reference to turbidity, of these waters. The writer wishes to state that the water of the Sacramento, although very turbid for short periods each year, was comparatively low in turbidity during the period of the experiments. In fact, before concluding the experiments it was deemed advisable to try the addition of fine clay to the water to simulate these very high turbidities. The lake water at Milwaukee varied in turbidity from 6 to 160 parts per million whereas the Sacramento River water turbidities ranged from 10 to 200 parts per million. The writer does not believe, therefore, that any difference in conclusions may be properly attributed to this factor. In fact, the writer's observations indicate quite the opposite conclusion, namely, that waters of low turbidity require higher velocities and longer periods of agitation than do more turbid waters. Prior to the Sacramento studies, observations were made with different waters of varying turbidity, color, alkalinity and hydrogen ion concentration, and, with the possible exception of very turbid waters, we did not find any waters which were not more effectively and economically coagulated by the type and period of agitation which we have described.

The water treated at the San Pablo Filter Plant of the East Bay Water Company of Berkeley, California, is very similar in character

to Lake Michigan water. We found at this plant that we were enabled to reduce the dosage of alum nearly 50 per cent by simply increasing the period of agitation from approximately five minutes to a period of fifteen minutes. The design of the mixing and coagulating basins in this plant, however, is such that only a portion of this saving is possible at the present time. Further extension of the mixing period will necessitate rather extensive changes, involving difficult construction work.

A similar experience was recently encountered at the filtration plant at Eureka, California. At this plant a water of high color and low alkalinity is handled. The coagulating basin is very small and there is but slight provision for agitation or mixing. A 3-liter sample of water removed from the outlet end of the sedimentation basin showed practically no floc and was quite turbid. This sample was agitated by imparting to it a swirling motion and in about two minutes a heavy floc made its appearance. This it seemed was a most remarkable demonstration of the effectiveness of motion in the coagulation of water.

Mr. Hoover's studies and observations in the field of water softening are always interesting and instructive. In his paper he shows that the usual operating differences in temperature exert a very material effect in the effectiveness of softening with chemicals, especially for the shorter periods. In this connection the writer wishes to point out that, whereas the chemical and physical reactions involved in the coagulation of water with alum on the one hand and the softening with chemicals on the other hand are similarly influenced by agitation, they apparently are not similarly influenced by changes in temperature. Well-controlled coagulation experiments in our laboratory with waters varying from practically freezing to boiling temperatures gave almost identical results. These results are confirmed by those recently published by Baylis in this JOURNAL (May, 1923) in connection with his observations in the coagulation of the water of Gunpowder River. He states that "There is every indication that temperature alone has very little effect." These observations of Baylis and also my own are not in agreement with earlier published references on this subject.

In conclusion, the writer wishes again to affirm his faith in mechanical mixing devices, particularly circular coagulating basins, as evolved from the Sacramento experiments. The studies and conclusions of Mr. Hoover constitute further justification of this departure from standard practice.

# THE HYDROGEN ION CONCENTRATION OF LIME TREATED WATER AND ITS EFFECT ON BACTERIA OF THE COLON-TYPHOID GROUP

By R. D. Scott[1] and G. M. McClure[1]

It has been observed over a considerable period of time that lime treatment of water results in a marked lowering of its bacterial content. Hazen (1888) at the Lawrence experiment station noted a high percentage removal of bacteria from sewage, following lime treatment. Fuller (1899) conducting tests on the treatment of the Ohio river water noted an effective bacterial removal after the addition of lime, but attributed it to coagulation and sedimentation. The first work on the lime treatment of water with regard to removal of organisms of the colon-typhoid group was that of Houston (1911) who found that, following the addition of sufficient lime to Thames river water to leave a slight excess, Bact. coli were destroyed in from five to twenty-four hours. Hoover and Scott (1913) confirmed Houston's results and found also that both Bact. coli and Bact. typhosum were destroyed following the addition of just enough lime to change bicarbonates to normal carbonates.

A reasonable explanation of lime sterilization, in the light of recent research on the behavior of bacteria in media of varying hydrogen ion concentration, is that it is largely due to the low hydrogen ion concentration of lime treated water.

The following references support this view: Shohl and Janney (1917) found that Bact. coli in urine were destroyed at pH 9.2 to 9.6 and that Bact. typhosum showed no growth at pH 8.8. Schoenholz and Meyer (1921) using several strains of Bact. typhosum in broth cultures buffered to from pH 8.6 to 8.9 noted a removal of 99 per cent. Neilson and Meyer (1921) working with buffered peptone solutions found that Bact. typhosum was destroyed at pH 9.2 to 9.4. Using higher concentrations of peptone they consider that pH 9.6 to 9.8 may be necessary. Scheer (1922) using phosphate buffer solutions found that Bact. coli were destroyed in three hours at pH 9.65 and in twelve hours at pH 9.43. At pH 9.32 the organisms were not killed in twenty-four hours. Cohen, (1922) using dilute buffer solutions observed Bact. typhosum sterilization in

[1] Ohio Department of Health, Ohio State University, Columbus, Ohio.

twenty-four hours at pH 9.5. He found that Bact. coli survived at this pH. Whipple (1922) in a review of the work of Houston attributes the bacterial effect of lime treatment to hydrogen ion concentration.

## EXPERIMENTAL WORK

The work described in this paper was carried on for the purpose of studying the relation of the hydrogen ion concentration of treated public water supplies to their Bact. coli content. As a preliminary a sample of river water was treated with varying amounts of lime and the alkalinity and pH then determined. Results are shown in table 1.

TABLE 1

*pH of sample of Scioto River water after lime treatment*

| GRAINS PER GALLON 92 PER CENT CaO | ALKALINITY | | | pH 24°C. |
|---|---|---|---|---|
| | Phenolphthalein | Total | Caustic | |
| | *p.p.m.* | *p.p.m.* | *p.p.m.* | |
| 0 | 0 | 117 | 0 | 7.45 |
| 2.92 | 6 | 55 | 0 | 8.71 |
| 4.38 | 10 | 36 | 0 | 9.35 |
| 4.96 | 15 | 34 | 0 | 9.38 |
| 5.84 | 17 | 32 | 2 | 9.56 |
| 7.30 | 47 | 56 | 38 | 10.35 |

Six Ohio water purification plants were then selected in which the treatment employed was such that a wide range in pH would be covered. Three of these plants use lime to the extent of complete lime softening, two use smaller amounts and one uses no lime. Samples of settled water were collected from these plants, representing water after coagulation and softening, if employed, but prior to either filtration or chlorination. These samples were collected by the plant operators and mailed at once to the Department laboratory, being received within twenty to forty-four hours after collection. On receipt of the samples determinations were made immediately of Bact. coli, alkalinity and pH.

In making the alkalinity and Bact. coli determinations, Standard Methods of Water Analysis of the American Public Health Association were followed. All aerobic non-spore forming organisms which fermented lactose with gas production were classed as Bact. coli, no attempt being made at further sub-division. Gas formers recorded in the tables as not of the colon group failed in every instance to grow on Endo, and were presumably anaerobes.

## METHOD OF MEASUREMENT OF pH

In measuring the pH values, the electrometric method, using the hydrogen-electrode, was employed. A type "K" Leeds and Northrup potentiometer was used, measurements being made against a normal potassium chloride-calomel electrode.

A Hillebrand electrode was used in a hydrogen cell of 25 cc. capacity. Commercial electrolytic hydrogen gas, purified by bubbling

TABLE 2

*Filter influent samples (low hydrogen ion concentration)*

| PLANT | DATE COLLECTED | ALKALINITY | | | pH | BACT. COLI (FIVE 10 CC. TUBES) | |
|---|---|---|---|---|---|---|---|
| | | Phenol-phthalein | Total | Caustic | | Positive tubes | Gas formers other than Bact. coli |
| | *1923* | *p.p.m.* | *p.p.m.* | *p.p.m.* | | | |
| Youngstown | March 26 | 38 | 48 | 28 | 10.44 | 0 | 0 |
| | March 27 | 35 | 44 | 26 | 10.36 | 0 | 0 |
| | April 2 | 29 | 39 | 19 | 10.19 | 0 | 0 |
| | April 3 | 29 | 39 | 19 | 10.20 | 0 | 0 |
| | April 10 | 30 | 49 | 11 | 9.73 | 0 | 0 |
| | April 11 | 40 | 52 | 28 | 10.32 | 0 | 0 |
| | April 16 | 25 | 32 | 18 | 10.18 | 0 | 0 |
| | April 17 | 28 | 36 | 20 | 9.82 | 0 | 0 |
| | April 23 | 30 | 40 | 20 | 10.05 | 0 | 0 |
| | May 1 | 25 | 35 | 15 | 10.30 | 0 | 0 |
| Defiance | March 28 | 35 | 48 | 22 | 10.36 | 0 | 1 |
| | March 30 | 18 | 36 | 0 | 9.69 | 0 | 4 |
| | April 4 | 22 | 35 | 9 | 9.17 | 0 | 2 |
| | April 12 | 31 | 46 | 16 | 10.32 | 0 | 0 |
| | April 13 | 25 | 42 | 8 | 9.88 | 0 | 1 |
| | April 18 | 20 | 35 | 5 | 9.77 | 0 | 0 |
| | April 19 | 16 | 34 | 0 | 9.29 | 0 | 2 |
| | April 25 | 28 | 41 | 15 | 10.33 | 0 | 1 |
| | April 26 | 28 | 42 | 14 | 10.27 | 0 | 0 |
| | May 2 | 31 | 48 | 14 | 9.88 | 0 | 1 |
| | May 3 | 31 | 48 | 14 | 10.02 | 0 | 0 |
| | May 10 | 25 | 44 | 6 | 9.78 | 0 | 0 |
| Bellaire | April 12 | 45 | 52 | 38 | 9.81 | 0 | 1 |
| | April 16 | 29 | 41 | 17 | 10.33 | 0 | 0 |
| | April 18 | 21 | 34 | 8 | 9.95 | 0 | 0 |

through alkaline pyrogallol and potassium permanganate solutions, was passed over the electrode in a stream vigorous enough to surge the solution about the electrode. The entire set-up was checked before and after each series of measurements by means of a standardized

TABLE 3

*Filter influent samples, (high hydrogen ion concentration)*

| PLANT | DATE COLLECTED | ALKALINITY | | | pH | BACT. COLI (FIVE 10 CC. TUBES) | |
|---|---|---|---|---|---|---|---|
| | | Phenol-phthalein | Total | Caustic | | Positive tubes | Gas formers other than Bact. coli |
| | *1923* | *p.p.m.* | *p.p.m.* | *p.p.m.* | | | |
| Cincinnati | March 26 | 8 | 35 | 0 | 8.30 | 3 | 0 |
| | March 27 | 8 | 35 | 0 | 9.12 | 5 | 0 |
| | April 2 | 8 | 35 | 0 | 8.94 | 3 | 2 |
| | April 9 | 8 | 40 | 0 | 8.63 | 3 | 0 |
| | April 16 | 6 | 40 | 0 | 8.70 | 5 | 0 |
| | April 17 | 2 | 39 | 0 | 8.08 | 5 | 0 |
| | April 24 | 8 | 32 | 0 | 8.25 | 5 | 0 |
| | April 30 | 6 | 39 | 0 | 8.71 | 5 | 0 |
| | May 1 | 8 | 48 | 0 | 8.90 | 5 | 0 |
| Niles | March 28 | 8 | 36 | 0 | 9.14 | 5 | 0 |
| | March 29 | 5 | 34 | 0 | 9.00 | 5 | 0 |
| | April 4 | 8 | 35 | 0 | 8.20 | 5 | 0 |
| | April 11 | 9 | 42 | 0 | 8.77 | 5 | 0 |
| | April 18 | 9 | 32 | 0 | 8.70 | 5 | 0 |
| | April 25 | 5 | 28 | 0 | 8.54 | 5 | 0 |
| | April 26 | 4 | 24 | 0 | 8.65 | 5 | 0 |
| | May 3 | 15 | 26 | 4 | 9.19 | 0 | 1 |
| Sandusky | March 28 | 0 | 95 | 0 | 7.88 | 5 | 0 |
| | April 5 | 0 | 80 | 0 | 7.35 | 5 | 0 |
| | April 11 | 0 | 86 | 0 | 7.88 | 5 | 0 |
| | April 19 | 0 | 82 | 0 | 7.67 | 5 | 0 |
| | April 25 | 0 | 80 | 0 | 7.61 | 5 | 0 |

buffer solution. The pH values were calculated from the formula: $\text{pH at } 25°\text{C.} = \frac{\text{E. M. F.} - 0.283}{0.0596}$. In case the temperature at which a measurement was made varied from 25°C., a correction was made.

In practically all the samples worked with, there was a slight, gradual increase in the measured E.M.F. with continued passage

of hydrogen through the solution. This was not great enough, however, to prevent readings of the E.M.F. to an accuracy of plus or minus 0.2 millivolts, corresponding to a pH correction of about plus or minus 0.01.

The results of the examination of the samples are shown in tables 2, 3 and 4.

TABLE 4

*Raw waters*

| PLANT | SOURCE OF SUPPLY | DATE COLLECTED | ALKALINITY | pH | BACT. COLI (NUMBER OF POSITIVE TUBES) | |
|---|---|---|---|---|---|---|
| | | | | | Five 1 cc. tubes | Five 0.1 cc. tubes |
| | | *1923* | *p.p.m.* | | | |
| Youngstown | Mahoning River | April 24 | 5 | 5.05 | 5 | 5 |
| | | April 30 | 12 | 7.03 | 5 | 5 |
| Defiance | Maumee River | May 2 | 165 | 7.96 | 2 | 1 |
| | | May 10 | 175 | 8.21 | 4 | 0 |
| Bellaire | Ohio River | | | | | |
| Cincinnati | Ohio River | April 30 | 35 | 7.26 | 5 | 1 |
| | | May 2 | 40 | 7.41 | 5 | 0 |
| Niles | Mahoning River | April 25 | 19 | 6.44 | 5 | 5 |
| | | April 28 | 28 | 7.02 | 5 | 5 |
| | | May 3 | 8 | 4.33 | 5 | 5 |
| Sandusky | Sandusky Bay of Lake Erie | April 25 | 98 | 8.05 | 2 | 0 |
| | | May 2 | 92 | 7.57 | 5 | 5 |

## DISCUSSION

The plants from which the samples were collected may be divided into two classes on the basis of the pH of the settled waters. In the samples recorded in table 2 the pH was usually greater numerically than 9.5, while in the samples shown in table 3 the pH was constantly less numerically than 9.5. It follows that the actual concentration of hydrogen ions in the samples of table 2 is *less* than in the samples of table 3.

The bacterial results are in very marked contrast. Bact. coli were not found in 50 cc. volume in any sample from the first group

of plants (low hydrogen ion concentration), but were present with one exception in 50 cc., and usually in 10 cc. volumes in the samples from the second group of plants. (Higher hydrogen ion concentration.) A total of 47 samples of settled waters was examined. The Bact. coli content of the raw waters is shown in table 4. One cubic centimeter tubes were as a rule positive. The inference is strong that the contrasting results on these settled water samples are accounted for entirely by differences in pH.

If this conclusion is sound, that organisms of the colon-typhoid group do not survive long in waters so treated that the hydrogen ion concentration is lower than about pH 9.5,[2] (the numerical value of pH is here greater than 9.5), then it would seem that water purification plants, which employ a treatment process such that the settled water attains a pH of this order, possess a distinct advantage over other types of plants. While the effluents from the latter type of plants may as a result of efficient filtration and chlorination be entirely satisfactory bacterially, and fully equal in this respect to that of the first type of plants, yet one type has two factors of safety: filtration and chlorination, while the other has the additional factor of low hydrogen ion concentration.

## NATURE OF TREATMENT REQUIRED FOR LOW HYDROGEN ION CONCENTRATION

When a natural water is treated with lime to such an extent that all of the alkalinity is in the form of normal carbonates, as indicated by the phenolphthalein alkalinity being just one-half of the total or methyl orange alkalinity, then its pH will be, at ordinary temperature in the neighborhood of 9.5. This value was based on the following data: Laboratory treatment of water with lime, table 1. Determination of the pH of dilute sodium carbonate solutions.[3] Determination of pH of treated public water supplies, tables 2 and 3.

The hydrogen ion concentration expressed by pH 9.5 is probably not low enough to be effective under all conditions in removing

[2] As the temperature at which the pH was determined was considerably higher than that of the samples as collected, the actual pH values were less numerically than recorded. Thus in some cases the pH was about 9.1 instead of 9.5 as recorded.

[3] It was observed that the pH of dilute $Na_2CO_3$ solutions at 22°C. was:

| Alkalinity, p.p.m. in terms of $CaCO_3$ | 50 | 100 | 500 |
|---|---|---|---|
| pH | 9.55 | 10.20 | 10.50 |

organisms of the colon-typhoid group, neither is it practicable in plant control to hold the alkalinity exactly in the carbonate form; it is necessary in practice to carry several parts per million of caustic alkalinity, otherwise bicarbonate alkalinity will at times be present with a resultant increase in hydrogen ion concentration. Temperature changes have a material effect. It was found that increasing the temperature of a sample of softened water from 8° to 27°C., changed the pH from 9.89 to 10.32. Thus in cold weather higher caustic alkalinity would be required to produce a bacterially safe pH.

It is believed that pH 10.0 to 10.3 should be sufficient to provide a reasonable margin of safety. This pH is ordinarily attained through the addition of lime to the extent of a caustic alkalinity of 10 to 20 p.p.m. The caustic alkalinity may be and at some plants is removed by carbonating.

## CONCLUSION

References are cited which indicate that bacteria of the colon-typhoid group are destroyed in media of low hydrogen ion concentration, the limiting value being in the neighborhood of pH 9.5.

Results of the examination of samples from municipal water purification plants are presented which indicate that this limiting pH here also applies.

The point is raised that those plants employing a process, for example, lime treatment, in the course of which the water attains a pH of this order, may possess an advantage over others in bacterial efficiency.

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# SOME WATER TREATMENT PROBLEMS IN ONTARIO[1]

By A. V. Delaporte[2]

The treatment of the majority of water supplies of Ontario presents few new problems to the designing engineer. The Great Lake waters are clear and colorless with the exception of the Detroit River and possibly Lake Erie. The problems involved in the treatment of these waters comprise the removal of effects of local pollution and occasional turbidity caused by storms. A number of municipalities use springs, spring creeks or deep wells. Most of these present no particular problem. Some, however, require treatment for the removal of iron, excessive $CO_2$, $H_2S$ or for softening. In Northern Ontario and in the Ottawa and Trent River systems, which might be described as peaty waters, there is an appreciable amount of organic matter and a definite colour. These waters generally carry but slight turbidity, excepting storm water, and are comparatively soft. The Central and Western drainage systems such as the Thames, the Grand River and Kettle Creek, have a high turbidity and are classed as hard waters, that is they have a high incrustant content. Some of the smaller lakes or bays that are utilized as municipal supplies require treatment for plankton.

A paper on pretreatment of water was given by Messrs. Dallyn and Delaporte before this Association at the last mid winter meeting and there have been few developments since. It has, however, been demonstrated that a fine filter will retain in the form of hydrate all the aluminium added as alum, irrespective of the pH value (within certain limits), agitation or time of reaction. This would seem to limit the value of the determination of the pH value in filter operation to preventing over-dosages or adjusting the reaction of a water to prevent corrosion. This is true of practically all the waters of the province with the exception of those classed as peaty waters. There seems to be a definite relationship between the volume of floc required to precipitate turbidities and remove color and the volume

[1] Presented before the Canadian Section meeting, February 29, 1924.

[2] Chemist, Provincial Board of Health, Ontario, Canada.

of turbidity and depth of the color, irrespective of the pH value. In other words, a definite amount of an alum floc can only absorb and remove a definite amount of color or turbidity in a certain time. If there is a higher color or greater turbidity than is being removed at a definite dosage then the dosage must be increased, or if there is more alum floc than is necessary to remove the color or turbidity then the dosage can be decreased irrespective of the pH value. This is not true at all times. Traces of some substances appear to retard or inhibit the above reactions.

In the conversion of wood fibre or cellulose into peat, lignite and coal, there seems to be a very gradual elimination of the hydrogen, oxygen, and carbon with the result that the substance undergoing lignification becomes relatively rich in carbon. The carbon which is thrown off in combination with oxygen and hydrogen is probably responsible for those organic acids found in peaty waters. These acids are sometimes exceedingly complicated bodies such as ulmic acid ($C_{18}H_{14}O_6$) or crenic acid ($C_{12}H_{12}O_8$). In other cases simpler bodies such as glycollic acid ($C_2H_4O_3$) or formic acid ($CH_2O_2$) occur. These acids are all derived from peat. Complete oxidation would convert the cellulose into carbonic acid and water, but there are many intermediate stages in the process. One of the stages appears to be the formation of a substance which has been called formyl cellulose. This substance is only slightly soluble in water and can only exist in soft waters which contain little or no $CO_2$. Waters containing formyl cellulose are generally on the border line between acidity and alkalinity and have a corrosive action on iron, zinc or lead pipes. Such a water takes up oxygen readily from permanganate and when distilled yields a volatile acid which shows the characteristics of formic acid. When treated with lime a yellow colored deposit settles out, the oxygen consumed value drops sometimes to the extent of four-fifths and on distillation no volatile acid is evolved. This would appear to offer a possible method of treatment of this type of water. Some of these organic compounds do not affect the results of titrations with standard acids and alkalies but have an effect on the precipitation of and flocculation of aluminium hydrate, retarding the reaction and in some instances preventing the formation of a floc. This was illustrated in experiments with the chemical precipitation of sewage. Some samples would give an excellent floc and clear supernatant liquor and others, for no apparent reason, would not give an alum floc. It is not safe to predict what will

happen upon the addition of alum to waters containing organic matter. Hydrogen ion concentration values, acidities or alkalinities determined by use of dyes as indicators give no indication of the presence of these substances. The only satisfactory method of determining what will happen is by actual treatment with alum. The Provincial Board of Health has recently secured an electrolytic apparatus for both acidimetric and alkalimetric estimations and determinations of hydrogen ion concentration. By the use of this apparatus it is hoped that it will be possible to determine the presence of organic acids to which the indicators commonly used are not sensitive.

Reazin Lake, which is the source of Burkes Falls water is a water of this class. It is very interesting from several different aspects. An analysis shows the following results, in parts per million:

| TOTAL SOLIDS | RESIDUE AFTER IGNITION | $Fe_2O_3$ | $Al_2O_3$ | CaO | MgO | Cl | $SO_3$ | Na + K | $H_2S$ | OXYGEN CONSUMED | FREE AMMONIA | ALBUMINOID AMMONIA | NITRITES AND NITRATES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 121.6 | 35.0 | 2.3 | 0.6 | 6.5 | 5.3 | 2.0 | 5.3 | Trace | 0.61 | 12.9 | 0.4 | 2.3 | 0.0 |

The $H_2S$ was determined over twenty-four hours after taking the sample, so that that figure is probably low and the $SO_3$ high.

This water also contains an aerobic, spore forming, lactose fermenting bacillus. This organism has a central spore and is non motile. It appears to possess all the B. coli reactions and has its appearance in growth, with the possible difference that some colonies are slightly larger and more granular than typical B. coli colonies. Spores do not show in new cultures, but on keeping the culture forty-eight hours spores develop.

Some years ago a Bell filter was installed on this supply and through some misunderstanding it was not operated. The Provincial Board is at present assisting with an experiment with this filter. This supply and the operation of this filter will provide a fertile field for research into waters of this character, as this water contains more peaty matter in solution than any other supply in Ontario. The loss on ignition of 86.6 p.p.m. was due almost entirely to oxidation of dissolved organic matter. At an early date more data will be available dealing with the problem of treating this class of water.

Two of the filter plants operating on Lake Ontario have experienced difficulties, although the trouble was from different sources. One filter, of the gravity mechanical type, encountered serious difficulty in operating during the period a year or two ago when the lake was filled with dead or dying fish known as ale-wives. The filtering surface in two or three hours would become almost impervious owing to a slimy substance mixed with fish scales which appeared to be the product of the decomposition of the fish. Various expedients were tried; the difficulty was finally overcome by rearranging the settling basin, which, after very slight alteration, retained the substances which were the cause of the trouble. Recently a slow sand plant encountered a similar difficulty. The water passed through a sedimentation tank to the filter. After some stormy weather the filters could only be operated for about eight hours. A very fine turbidity passed through the settling tank and stopped the filters. This was a suspension of blue clay, apparently caused by the scour of wave action on a blue clay bottom. It appeared to settle quite readily in the laboratory and by rearrangement of the baffles in the basin it is hoped to prevent a recurrence of the trouble. Filter units which are equipped with settling basin, coagulating basins or storage basins to provide for the pretreatment of the water before filtration are able to meet such conditions when they arise. These filters, had they been without settling basins, could not have continued to operate.

It has been generally accepted that turbidities of over 50 p.p.m. cannot be economically removed by filtration alone, and that for higher turbidities it is essential that the turbidity be reduced by settling before filtration. The type and amount of turbidity which will overload any plant varies with the plant arrangements and retention tanks prior to filtration offer distinct advantages to the plant operation in providing flexibility in management and economy in alum and wash water.

At Chatham, great difficulty has been experienced in filtering Thames River water after storms, even with a settling period of several days. The settling basins were unable to produce a water suitable for filtration. In March, 1923, the municipality, assisted by the Provincial Board, undertook an experiment to determine what could be done. A baffling system of sheet piling was constructed in the storage reservoir. Under average conditions it provided an observation period of two hours and a final settling

period of twenty-four hours from the time the alum was added. The preliminary storage did not reduce the turbidity below 200 p.p.m. To secure a filtered water with a turbidity of less than 10 it was necessary to reduce the turbidity of the filter influent to less than 75 p.p.m. The initial turbidities varied from 150 to 1500 p.p.m., the alkalinity from 148 to 182 p.p.m. and the pH value from 7.9 to 8.2. A dosage of 5 g.p.g. of alum reduced the turbidity at the end of twenty-four hours storage to 50 to 60 p.p.m. from 200 to 600, and pH value to 6.8 to 7.2. The resulting filter effluent under these conditions had a turbidity of less than 10 and was physically unobjectionable.

At the plant, experiments were conducted with sulphuric acid and alum for the purpose of manipulating the pH value. These demonstrated that, irrespective of the pH value, at least 4 g.p.g. of alum were necessary to precipitate the turbidity and that the acid would be but an additional expense. Other experiments were made with lime, soda ash and permutit. The results with the lime showed that, unless lime was added in excess, the reacting and settling period took several hours, accompanied by an increased pH value. Similarly the soda ash and permutit appeared to be of no benefit in this respect.

Experiments at Essex, Forest, and Richmond Hill with aeration have been undertaken, with some success, in endeavors to remove $H_2S$, excessive $CO_2$, iron or taste from decomposing organic matter. Owing to the severe winter in Ontario, aeration by spraying the water to be aerated is not practicable. Diffuser plates, such as are used in the activated sludge process, were installed and air pumped through the diffuser plates by a small air compressor.

The town of Essex secures its water supply from three deep wells. One, the Garrow well, is situated about a mile from the pump house. The other two, designated as the North and South wells, are located within the pump house in the centre of the town. All three wells are pumped into a reservoir, 25 feet in diameter and 50 feet deep, located under the pump house. This is connected by a 10-inch opening with another reservoir, or pump well, elliptical in shape and 25 feet deep..

The attention of the Board was first attracted to this supply by the extraordinary chlorine requirement for sterilization. Laboratory tests showed that it took 35 to 40 p.p.m. of chlorine to give a trace of residual chlorine with this water. Analysis of the water showed that it contained 1.4 to 2 cc. of dissolved oxygen per litre and 9 to 10.5 p.p.m. of $H_2S$.

For aeration purposes a diffuser plate 1 foot square was placed at a depth of 30 feet in the centre of the large reservoir. Air was supplied from an air compressor delivering 5 to 7 cubic feet of air per minute.

After aeration was commenced, it was found possible to reduce the rate of application of chlorine to 4.1 pounds per twenty-four hours, a net saving of over 50 pounds of chlorine per day. This gave a trace of residual chlorine at all times. The dissolved oxygen in the water was increased from 2.0 to 4.5 cc. per litre, the $H_2S$ was entirely removed and the $CO_2$ was decreased from 6.6 p.p.m. to 3.9 p.p.m. If the reservoir had been of a design which facilitated aeration and there had been a greater supply of air available, it is certain that the chlorine dosage could have been reduced still further.

An experiment at Forest was undertaken to determine the feasibility of aerating a highly carbonated deep well supply (40 p.p.m. $CO_2$) in order to eliminate objectionable taste and certain medicinal properties. The free $CO_2$ was entirely eliminated with fifty-five minutes aeration and the dissolved oxygen increased from 2.1 to almost 9.0 cc. per liter in the same period. This was accompanied by a complete removal of the objectionable properties of the water.

The town of Richmond Hill secures its water from a spring creek. The creek is dammed to form a shallow lake several acres in extent. This pond during the summer is filled with various types of aquatic plants, becoming practically a marsh. The surface becomes very warm and the heavy weed growth aids stratification by tending to prevent movement of the water. Water from this pond is passed through a mixing chamber, sedimentation tank, and gravity mechanical filters to a clear water well. From there it is pumped to a stand pipe. The water consumption is very small in the town, so that the ordinary plant operation is to filter and pump a few hours on two or three days a week just enough water to fill the stand pipe and clear water well. Consequently the water is in the system for possibly a month and in the outer edges of the town probably six weeks.

During the winter, when the creek and pond were covered with ice, the water in the mains developed an objectionable color, odor and taste due to iron and organic matter. The application of alum to the raw water was discontinued and a diffuser plate 1 foot square was placed in the sedimentation chamber in such a position as to give a maximum of agitation, compressed air being forced through

from a small gasoline engine which had been converted into an air compressor. Despite the fact that the amount of air available was insufficient and that the chemical results show only slight improvement in the water, the physical improvement was very marked and out of all proportion to the chemical improvement noted. A portion of the iron in the raw water was precipitated and was removed on the filters. The dissolved oxygen was increased from an average of 0.3 to 2.3 cc. per liter and the organic matter was partially oxidized. This resulted in practically an entire removal of the objectionable physical properties of the tap water. The odors, taste, color and sediment which developed in the mains before aeration disappeared entirely or were reduced to such an extent as not to be objectionable. Only once or twice since aeration was commenced has sediment or odor developed in the water in the mains.

In midsummer, the conditions noted in the winter also prevail, in part due to the lack of motion in the pond. The water at the bottom, protected from the heat of the sun and from circulation or mixing with the warmer surface water by the weed growth, presents all the characteristics of the water during the winter months.

Aeration is not carried to completion at Richmond Hill due to the small capacity of their air compressor. The results obtained indicate that with adequate aeration the objectionable constituents could be entirely eliminated. This supply would be materially improved if there were a greater consumption of water in the town so that the plant operation would be continuous and the water would not be standing in the system, producing what amounts to dead end conditions.

Complaints as to taste are ever present. It is in part a psychological problem. There are always with us those unfortunates who can be counted on to detect taste in water if there is any chance, however remote, of a taste. Disregarding them, there is a wide difference in the sensitiveness of the sense of taste of different people, and with the same people with different substances. It may be generally accepted that most people cannot detect the taste of free chlorine under 0.4 p.p.m. introduced into pure lake water, and only a few hypersensitive people can detect a chlorine dosage under 0.3 p.p.m. Therefore, if the chlorine dosage is adjusted so that there is never more than 0.3 p.p.m. residual chlorine there should be no complaints of a chlorine taste except where some local situation is involved. The so-called chlorine taste is caused by minute traces

of chlorine compounds of tar derivatives, the so-called trichlorphenols and chlorine compounds of certain substances of unknown constitution and origin which occasionally occur in a chlorinated water. These tastes are offensive and no certain method of elimination of these compounds can be offered from the water works standpoint. It is sometimes beneficial to increase the dosage of chlorine. A number of investigators are working on this problem now. At present the only sure solution is to eliminate the trouble at its source and prevent the disposition of water carrying these objectionable constituents in a place where it can pollute a municipal water supply. Incidentally, gas works and coking plants do not need to dispose of this water by discharging it into the water courses of the Province. All the waste water can be utilized in quenching the coke, provided storage is available.

The tastes and odors from the breaking up of organic forms are sometimes very objectionable. In an experiment recently carried on at a municipality using a small weedy river as a source of supply it was noted that the adjustment of the chlorine dosage eliminated the weedy taste. Unfortunately, the color standards for the control of the chlorine dosage were made for summer conditions. This winter, with a clear water, the standards are off color and have led to an over-dosage of chlorine which has been responsible for a real chlorine taste.

# PROGRESS REPORT OF COMMITTEE NO. 5 ON WATERSHED PROTECTION[1]

Surface water supplies are derived from catchment areas of widely varying character and hence the degree of water purification and water protection likewise vary between wide limits.

To illustrate these principles the Committee submits five contributions prepared by district engineers in the Bureau of Engineering of the Pennsylvania Department of Health.

These reports of observation and procedure cover typical or unique problems in Pennsylvania, ranging from the protection of practically uninhabited watersheds to the more extensive and complicated problems on watersheds where sewage and industrial wastes from densely populated districts are distinctly prejudicial to the sources of public water supplies.

The paper presented by Mr. Mark deals with watersheds practically uninhabited, but subject to chance contamination by hunters, fishermen and berry pickers. The reservoirs do not provide long-time storage. These watersheds are made subject to sanitary regulations for sportsmen's camps as well as routine patrol and inspections by the water company.

The case discussed by Mr. Glace is of an inhabited watershed, long-time storage facilities and intensive sanitary control. An interesting feature is the special authority conferred by the State Department of Health on a representative of the local water company for enforcement of sanitary regulations on the watershed.

The contribution of Mr. Matter considers a public water supply obtained from three streams, two of which are relatively clean, but the third is subject to sewage contamination and after storms is turbid. The storage afforded the two better sources of supply has

[1]This report contains contributions from five of the district engineers of the Bureau of Engineering, Pennsylvania Department of Health, prepared under the direction of Committee No. 5, W. L. Stevenson, Chairman, T. DeL. Coffin, Katonah, N. Y., J. A. Foulks, Newark, N. J., S. A. Greeley, Chicago, Ill., W. V. Locke, Boston, Mass., R. J. Newsom, Lynn, Mass., F. M. Randlett, Portland, Ore. and S. P. Senior, Bridgeport, Conn.

been considered sufficient, but the dangerous source of supply entered the reservoir at a point too near the intake to provide proper reduction in turbidity and bacterial content. The required safeguards, pending filtration, include enlargement of the main storage reservoir with relocation of the intake, construction of a small dam on the more dangerous stream, strict sanitary control of the watersheds, and disinfection of the water before delivery to the consumers.

A unique case is reported by Mr. Fortenbaugh. A water supply obtained from mountain streams is impounded in a series of storage reservoirs. A stream tributary to the upper storage reservoir was acid from mine drainage and has an unsewered village near its headwaters. When the city desired to intercept the acid mine drainage it was permitted, provided that a sufficient quantity of acid mine drainage be still allowed to enter the stream to act as a disinfectant, on account of the possible sewage contamination from the village.

The paper presented by Mr. Siebert considers the rather complicated problem of regulation of the discharge of sewage and industrial wastes on a large, densely populated watershed above the intakes of water filtration plants. The present contamination of the stream is so great that, at times, tastes and odors persist even after purification of the water by most elaborate and refined methods. Extreme care is necessary in the operation of the purification plants to prevent water of a dangerous character being served to the public. The policy adopted for protection of the watershed is interesting, since it recognizes the necessity of safe public water supplies and also gives due regard to reasonable economic requirements upon municipalities and essential industries.

The five contributions follow in the order above mentioned.

## PROTECTION OF THE WATERSHED OF WHITE DEER CREEK AND SPRUCE RUN, UNION COUNTY, PENNSYLVANIA

By Coleman B. Mark[2]

A water district flanking both banks of the West Branch of the Susquehanna River for a distance of eight miles has approximately

[2]District Engineer, Pennsylvania Department of Health.

20,000 consumers with an estimated average daily consumption of approximately 2,500,000 gallons of water. The supply is treated with chlorine gas.

The sources of supply are White Deer Creek and Spruce Run. The former has a watershed area of approximately 40 square miles and the latter approximately 13 square miles, almost all of which is owned by the Commonwealth of Pennsylvania and comprises part of a State forest reserve. The water company owns about 700 acres above the intakes, a lumber company a few hundred acres, there are a few private holdings and the remainder is owned by the Commonwealth.

On this watershed practically all of the virgin timber has been removed and to a large extent it is grown over with underbrush and second growth timber. A highway extends along this creek paralleling and occasionally crossing the stream. At some points vehicles are obliged to ford the stream. No lumbering operations are being carried on. The stream is fished during trout season and the shed is traversed also by berry pickers and hunters.

Spruce Run watershed is similar to that found on White Deer Creek. An almost impassable wagon road extends through the shed. All virgin timber has been removed and no lumbering operations are carried on. Fishermen, berry pickers and hunters frequent the shed in season.

On both watersheds numerous club houses and cabins have been built by campers and hunters. There are also tent camps throughout the area. All of the camps presumably are under the supervision of the State Forest Ranger, and campers and hunters remaining over night on the shed are requested to secure a permit from the Department of Forests and Waters. Fishermen and hunters going on the shed for only a single day are not required to secure a permit.

In order that the Department of Forests and Waters and the State Department of Health might work in harmony and understanding in preserving the public health, these departments have jointly set up a procedure for the control of camping on watersheds of streams in State forests from which water supplies are taken for the public without filtration. This procedure is as follows:

**The general restrictions shall apply only to streams having more than 50 per cent of the water-shed area above the intake dam within State forests. Water-shed area is to be considered in three zones.**

The first zone is to include all territory within the water-shed situated less than 1 mile, measured along the stream, above the intake dam, and no camping privileges are to be granted within this zone.

The second zone is to embrace all territory within the water-shed situated between 1 and 2 miles, measured along the stream, above the intake dam, and no camping privileges are to be granted within this zone unless an approved water-tight privy vault of concrete or stone masonry is provided at the camp in addition to the observance of the standard sanitary restrictions.

The third zone will include all territory within the watershed beyond the 2 mile zone by measurement along the stream above the intake dam. All camps within this zone are to be subject to standard restrictions.

Permanent camps situated within Zone One will be permitted to remain until expiration of existing leases, providing that they comply fully with the instructions set forth herein concerning camps located in the second zone.

Special inspections will be made by the State Department of Health to determine the degree of compliance with sanitary regulations at all camps situated in Zone One during the life of present leases and at all camps situated in Zone Two under existing leases or such camps as are hereafter authorized.

*Sanitary considerations for a camp site:* Ground should be comparatively level and the soil of an absorptive nature, that is to say, free from outcropping rock ledges and of sand or loam formation.

The tents or cabins should be at a distance of at least 50 feet from the main stream or tributary thereof and so situated that the natural direction for throwing wash and kitchen water would be away from rather than towards the stream.

The privy and garbage pits should likewise be on comparatively level ground and at a distance of at least 100 feet from the stream or tributary, unless a water-tight privy pit of concrete or stone masonry is provided, in which event the distance from the stream should be not less than 50 feet.

If it is intended to take water supply from a spring the camp should be located on lower ground than the spring and other camps further up the stream or slope should not be located within 300 feet of the spring. If a well is dug or driven the same procedure applies as to its location.

Water should not be dipped from a spring but a spring enclosure of wood or masonry should be constructed and provided with an overflow pipe or with a pump from which water can be obtained. The dug or driven well should be protected against surface contamination. Methods of protecting springs and wells against contamination are illustrated in the attached circular.

*Permanent camps:* All permanent camps shall be situated on comparatively level ground and at a distance of at least 50 feet from the main stream or tributary thereof. A suitable privy shall be provided at each permanent camp and situated at least 100 feet from the main stream or tributary thereof, and below the source of the camp water supply, excepting that if a water-tight vault of concrete or stone masonry is provided, the privy may be located 50 feet from the stream or tributary. Before camp is open the owners shall provide a quantity of hypochlorite of lime (chlorinated lime or "bleach") equivalent to one pound for each week the camp is to be occupied. Contents of privy vaults shall be thoroughly sprinkled with this chemical twice each

week the camp is occupied, using not less than ½ pound of the chemical at each application. After application of the chemical the contents shall be covered with a thin sprinkling of dirt. The contents of the privy vaults shall be removed and buried either promptly upon close of camp for the season or prior to opening the following season. Should vault become filled before close of camp, it shall be emptied promptly. Contents of privy vaults shall be buried at a point not less than 100 feet from a main stream or tributary, immediately upon removal, or they shall be burned.

A suitable hole not less than 18 inches in depth and at least 50 feet from a main stream or tributary shall be provided for garbage and all garbage shall either be thrown in this hole and covered with dirt or shall be burned.

Kitchen or wash water shall not be thrown into a spring or stream or upon the surface of the ground in the immediate neighborhood of a spring or stream.

*Temporary camps:* All temporary camps shall be situated on comparatively level ground and at a distance of at least 50 feet from a main stream or tributary thereof. At all temporary camps a suitable trench or pit at least 2 feet in depth shall be dug for sewage and such trench or pit shall not be within 100 feet of any main stream or tributary, nor above the source of the camp water supply. Earth from the pit shall be banked on the high side or upon the side away from the stream. Before camp is opened the owners shall provide a quantity of hypochlorite of lime (chlorinated lime or "bleach") equivalent to 1 pound for each week the camp is to be occupied. Contents of privy vaults shall be thoroughly sprinkled with this chemical twice each week the camp is occupied, using not less than ½ pound of the chemical at each application. After application of the chemical the contents shall be covered with a thin sprinkling of dirt. Should privy pit become filled another shall be dug at once. Upon completion of camp, the pit shall be refilled, excess dirt mounded over the top and rammed in place.

Garbage shall be burned or placed in a separate pit similar to that provided for sewage, but shall not be placed in the same pit. Kitchen or wash water shall not be thrown into a spring or stream or upon the surface of the ground in the immediate neighborhood of a spring or stream.

*General:* Upon close of camps of all classes, all inflammable rubbish and refuse shall be collected and burned.

All tin cans are to be crushed flat and buried.

The camp site is to be left in a neat and cleanly condition.

When campers are away from the camp site, particular care must be taken not to deposit any fecal matter or urine on the ground in the vicinity of any stream or spring.

Failure to observe sanitary regulations will be cause for vacation of the camp and revocation of the permit or lease.

Both the White Deer Creek and Spruce Run watershed are under continual menace due to the presence of habitations on the sheds and the traversing of the shed by travellers, hunters, berry pickers and fishermen. The existing reservoirs do not hold a great quantity of water and consequently a barrier, that might be interposed by

a large storage, is absent. The rugged character of the watersheds and the difficulty of access to certain parts of them, make it difficult to patrol, this being particularly the case during the hunting season when the greatest population occurs on the sheds. Vigilant supervision of the sheds by the water company in coöperation with the resident employees of the Department of Forests and Waters render these sheds reasonably safe, but it does not appear that such supervision can be most effectively exercised during the fishing and camping seasons. The occurrence of habitations, public roadways and the traversing of the watersheds by the public are liable to result in pollution of the water derived therefrom, and the State Department of Health deems it advisable and requires that all water served to the public therefrom must be treated with a chemical germicide. These requirements, with the regulation of sportsmen's camps on watersheds of public water supply systems, as set up jointly by the Department of Health and the Department of Forests and Waters, are considered sufficient protection for these watersheds, where the water is not filtered, but is chlorinated.

## WATERSHED PROTECTION, MONTROSE, SUSQUEHANNA COUNTY, PENNSYLVANIA

By I. M. Glace[3]

The Borough of Montrose, in Northeastern Pennsylvania, is supplied with water from a semi-artificial glacial pond having a capacity of 260 million gallons, a superficial area of 45 acres, and a watershed area of 1½ square miles, 80 per cent of which is under cultivation and the remainder wooded. On the shed there are 14 occupied properties, including farm houses, residences, a club house and railway station, 12 of which are provided with cesspools for the disposal of wastes and the other 2 with leaching privy vaults. The shed is crossed by a branch railroad, a trolley line, a State Highway and several township roads. In addition, the lake is utilized as an ice supply and, to a very minor degree for boating and bathing, due to disputed ownership.

Because of the comparative areas of the lake and shed, the flood-absorptive powers of the lake are very great; overflows occur but seldom and then only in small quantities. As a result the storage

[3]District Engineer, Pennsylvania Department of Health.

provided is almost 100 per cent effective, if such inhibiting effects on long-time storage as wind currents, stratification and winter short-circuiting, etc., are neglected. The color content of the water is low and zero turbidities are often recorded at the pump intake which is located not far from the outlet end of the basin.

To prevent, so far as possible, the contamination of this supply various measures have been instituted. The superintendent of the local water company has been deputized by the State Department of Health as a special health officer without pay and with jurisdiction over the watershed only. Monthly inspections of all properties on the shed are made by this superintendent who likewise, through his authority as a State representative, inspects and controls sanitary conditions on and around the lake during the ice cutting season. Coöperation of the street railway company has been secured to prevent nuisances at the station of the company which is a terminal point, and the township supervisors have constructed road drains to by-pass storm water from that portion of the shed nearest the dam and waterworks intake.

The water taken from the lake is disinfected with liquid chlorine and pumped to a distributing reservoir from which it reaches the town by gravity. Daily tests of tap water for residual chlorine are made by the company and weekly bacteriological analyses by a consulting bacteriologist and reports thereon are submitted weekly to the State Department of Health. In addition, samples for bacteriological and chemical examination, in the Laboratories of the Department, are collected by the Bureau of Engineering at irregular intervals and inspections of the chlorine apparatus are made at the same time.

The methods here used for the protection of the watershed are somewhat more intensive than is customary in Northeastern Pennsylvania, except, possibly, on the sheds of the Scranton Gas and Water Company, but they are of value in that they add an additional factor of safety to the major safeguards already provided by long-time storage and disinfection; and again, because they produce a favorable psychological effect on the consumers of the water. Considerable weight must be attached to this latter consideration because it is quite probable that all these protective measures could be abandoned without any serious detrimental effect on the health of the people in Montrose, provided, of course, that the present close and efficient control of the disinfection process be maintained.

It is the opinion of the writer that the comparative value of such intensive watershed work decreases in proportion to the increase in size and extent of the catchment area and quantity of water impounded; that is, where the storage capacity is to be measured in billions of gallons, and the watershed population in hundreds or thousands, scattered over an extensive area, the practical control of all the possible sources of contamination on the shed is not feasible and greater reliance must be placed on disinfection or, more probably, filtration and disinfection. On the other hand where really effective long-time storage is not provided—and very few municipalities in Northeastern Pennsylvania are so favorably situated from this standpoint as is Montrose—watershed protective measures become of greater value, although they can in no instance be considered to take the place of disinfection, which should, of course, be provided for all surface water supplies.

## WATERSHED PROTECTION, DUBOIS, CLEARFIELD COUNTY, PENNSYLVANIA

By L. D. Matter[4]

The City of DuBois, located in Clearfield County, derives its water supply from the watersheds of Muzz Run, Anderson Creek and Montgomery Run. The water is stored by means of an impounding basin, formed by an earthen dam across Anderson Creek below the junction of the three above named streams. This reservoir is located about 7 miles southeast of DuBois and has a capacity of about 85 million gallons. The City is supplied by gravity from this reservoir, the average daily consumption amounting to approximately 2 million gallons.

The watersheds of the three streams are contiguous and have a combined area of $24\frac{7}{10}$ square miles. The Muzz Run shed, $1\frac{1}{2}$ square miles in extent, is the smallest of the three, but has the greatest population. A large proportion of this shed is under cultivation and the water from this source is frequently muddy.

The other two watersheds are sparsely inhabited and are for the most part wooded. There is considerable hunting on these sheds with the result that during the hunting season the population is considerably increased.

[4]District Engineer, Pennsylvania Department of Health.

Unfortunately the intake in the reservoir is so located that very little water from Montgomery Run or Anderson Creek can enter. Under existing conditions, therefore, most of the water supplied to DuBois comes from Muzz Run, the least desirable of the three.

In view of the dangerous quality of the water supply taken from the reservoir, as evidenced by investigations of the watersheds and analyses of samples from the system, the State Department of Health in 1920 required the city authorities to install apparatus for the treatment of this water with a chemical germicide as a temporary protective measure. In addition, the city was required to make a study of the situation and report to the State Department of Health on permanent measures for the protection or purification of this supply.

In 1922 the city submitted plans for a proposed water filtration plant and a scheme for increasing the storage capacity of the reservoir. These plans were approved, but owing to the lack of sufficient funds neither project was started.

There were several reasons for this. In the first place, there were numerous complaints in DuBois about inadequate service in the higher portions of the city. Again, a survey made during the summer of 1922, indicated that enormous quantities of water were being lost within the city through leakage. These conditions being before the citizens at all times would naturally claim first consideration. It was, therefore, necessary for the city authorities to devise a program whereby the quality of the water could be improved and thereby comply with the orders of the State Department of Health and at the same time make the necessary improvements to insure adequate service throughout all parts of the city. With this end in view a program was submitted to the State Department of Health for approval in the spring of 1923. That portion of the program providing for the adequacy of service consisted of the construction of a storage reservoir on the highest point in the city and the undertaking of an intensive campaign towards the elimination of leakage in the distributing system.

The second portion of the program concerning the improvement of the quality of the water, which was submitted in lieu of the construction of a filtration plant, included the raising of the water level of the present reservoir approximately 3 feet, thereby increasing the capacity of the same from 85 to 132 million gallons; relocation of the intake to a point where water from the more de-

sirable streams could gain access to the same; the construction of a causeway upon Muzz Run so as to form a settling pool in which sediment carried by the Run would be deposited before the water entered the reservoir proper; the purchase of properties in the vicinity of the reservoir which would be affected by the raising of the water level; the construction of sanitary toilets or tight cesspools at all camps or habitations near any stream tributary to the reservoir; the continuance of the general cleanup program in the area adjacent to the reservoir and the removal of decayed wood and vegetation from the waters edge; the reforesting of the watersheds; and periodical inspection of the watersheds to be followed by a detailed report to the State Department of Health.

In approving this scheme the State Department of Health did not lose sight of the fact that the question of the quality of the of the water to be supplied was of primary importance nor that the city had been previously required to subject the water from this source to filtration. On the other hand, however, the Department had to consider that the city had to deal with the question of adequacy in addition to that of quality and that both problems had to be provided for from limited funds.

In view of these conditions, therefore, the decision of the Department was to the effect that the program should be approved and that the enforcement of the previously issued order requiring the construction of a filtration plant should be temporarily withheld pending the results obtained from the proposed improvements as provided in the above scheme.

## WATERSHED PROTECTION, ALTOONA, BLAIR COUNTY, PENNSYLVANIA

By J. Warren Fortenbaugh[5]

One of the most striking and unusual problems in watershed protection is that recently undertaken by the city of Altoona on the drainage area of one of the sources of supply for that city.

The city of Altoona, situated at the foot of the eastern slopes of the Allegheny Mountains, has a present population of approximately 65,000.

The water supply for the city, which is municipally owned, is secured from two surface streams rising on the eastern slopes of

[5] District Engineer, Pennsylvania Department of Health.

the Allegheny Mountains and flowing in a general southeasterly direction toward the city. The streams are impounded in three large reservoirs situated in the Horseshoe Curve. The uppermost has a capacity of 60 million gallons; the next a capacity of 365 million gallons; the lowest a present capacity of 600 million gallons. Arrangements at this latter reservoir are such that ultimately the breast of the dam can be raised to impound 1,600,000,000 gallons. It is thus seen that at present the city has a combined storage capacity of 1,025,000,000, which when the need arises, can be increased to 2,025,000,000 gallons.

The uppermost reservoir is used to supply entirely the higher elevations of the town, while the other ones supply the lower elevations, which include the business district and the Pennsylvania Railroad shops.

It is a significant fact that, although the combined storage period is long as based on either the runoff or the consumption, yet since all of the water must pass through the high level basin, the average retention period here is relatively short being approximately ten days. In addition to the advantages received through natural sedimentation, all of the water supplied to the city is treated at the several intakes with liquid chlorine.

Baker Run is heavily impregnated with acid mine wastes and during recent years the acid content of the water supplied to the city has been relatively high, running from 20 p.p.m. in the low service to 70 p.p.m. in the high service. This acid content has been responsible for attacking the plumbing and piping to an appreciable degree.

The Baker stream to which our attention will be confined, as the other stream is practically neutral as far as the mine drainage problem is concerned, is a typical mountain stream draining an area of 4 square miles above its confluence with the other stream. Ninety per cent of the shed is covered with second growth timber and underbrush, the remainder being cleared and inhabited land. Generally, the valley is narrow and steep, but at its upper end the slopes flatten out and at this point there is situated a small coal mining village, together with several farms. A highway also traverses the upper part of the catchment area. It was estimated at the time of a recent investigation that approximately 800 people lived on the watershed area.

Below the village and somewhat close to the upper end of the stream are the outlets from four mine openings. From weir measure-

ments taken at these mine mouths during the summer of 1921, a total of 375,000 gallons of acid mine water daily reached the stream.

At the expense of the city the municipal authorities decided to mitigate the conditions by bypassing all of this mine drainage, diverting it at the mine mouths and carrying it through terra cotta lines laid with bitulithic joints around the reservoirs, discharging it into the stream below them.

The Department of Health, on the other hand, while it realized the economic value of removing these substances from the water, also was cognizant of the germicidal value of these wastes in a stream having so large a watershed population. To this end it was decided that for the present only the drainage from the two lowermost mines, which were the ones having the highest acid content, might be removed, leaving that from the two upper mines to continue to reach the stream to counteract any chance pollution that might find its way there. This decision was made despite the facts that the city representative makes an inspection of the properties on the shed at stated periods and that the water is disinfected at the several intakes. Should the time arrive when the drainage from the highway and the village can be conducted to the sewer line, which must be extended a considerable distance to intercept it, the Department will then consider the advisability of removing all of the mine drainage from the stream.

While this problem may be somewhat peculiar to Pennsylvania, it does establish the contention that without this protective agency the sedimentation period plus chlorination is not sufficient treatment in the upper reservoir even with the watershed protection undertaken by the city. If all of the drainage from the village and the highway cannot be carried around the reservoirs when it is desired to remove the mine drainage entirely, filtration with chlorination may be necessary.

## PROTECTION OF THE WATERSHED OF THE BEAVER RIVER IN PENNSYLVANIA

By Christian L. Siebert[6]

The Beaver River, having a watershed area of 3040 square miles, joins the Ohio River at a point about 24 miles down stream from the

[6] District Engineer, Pennsylvania Department of Health.

city of Pittsburgh. Of the total watershed area 1784 square miles are in Pennsylvania and 1256 square miles are in Ohio.

The Mahoning and Shenango Rivers, having watershed areas respectively of 1099 square miles and 1080 square miles, join at New Castle, Pennsylvania, forming the Beaver River. Practically the entire Mahoning River watershed is in Ohio and almost all of the Shenango River watershed is in Pennsylvania.

The population residing on the watershed of the Beaver River is approximately 560,000, of which about 290,000 reside in Pennsylvania and about 270,000 in Ohio.

It is estimated that 335,000 of the total population of 560,000 contribute sewage to the Beaver River and its tributaries, the sewered population being estimated at about 165,000 in Pennsylvania and 170,000 in Ohio.

Waterworks with filtration plants located at Sharon, New Castle, West Pittsburgh, Ellwood City, Eastvale and New Brighton, all taking water from the Beaver River or its tributaries below the points of discharge of extensive municipal sewer systems, serve a population of approximately 150,000. It is estimated that about 315,000, of the total sewered population of 335,000 contributing to contamination of the Beaver River, discharge sewage above the intakes of waterworks serving the public.

The small streams of relatively good character in the lower Beaver Valley are not of sufficient size to be utilized as the sources of supply of the waterworks serving the population in the vicinity. Neither are the available ground water supplies sufficient to be utilized for public service, except in the instances of a few of the smaller municipalities.

The average minimum rate of flow of the Beaver River at New Brighton, where is located the waterworks intake farthest down stream, is about 150 cubic feet per second, which is equivalent to a dilution factor of only 0.47 cubic feet per second per thousand of the sewage contributing population, whereas the minimum allowable dilution factor ordinarily accepted is 4 or 5 cubic feet per second per thousand of the sewage contributing population, or about ten times the dilution effective in the Beaver River.

The extensive steel and allied industries located in the Youngstown and Sharon districts produce great quantities of industrial wastes which are discharged to the Mahoning River and the Shenango River. The ferrous sulphate liquors from tin-plate works

constitute a large part of the total industrial wastes and these wastes, during periods of relatively low stream flow, effect coagulation of much of the sewage load in the streams, and reduction in the velocity of the streams by a number of small dams accomplishes a very appreciable settling of the coagulated sewage content.

The Commonwealth of Pennsylvania is committed to the construction of a dam on the headwaters of the Shenango River, to be known as the Pymatuning Dam, all of the land required for this purpose having been either purchased or optioned. This dam is intended primarily to regulate floods and to store water for augmenting the extremely low flow of the Shenango River, this stream now being used over so many times for industrial purposes that the water in the river actually reaches a temperature of about 140°F. at Farrell. Increasing the low flow of the Shenango River will incidentally improve dilution of sewage and this factor has been considered in the determinations of the Bureau of Engineering of the Pennsylvania Department of Health concerning sewage treatment on the watershed of the Beaver River.

The modern water filtration plants treating water obtained from the Beaver River and its tributary, the Shenango River, require most skilful operation with constant laboratory control over the application of coagulants, artificial alkalinity and disinfectants and even with such a high degree of scientific supervision and with the most elaborately equipped filtration plants, there are times when it is practically impossible to provide a water that is free of tastes and odors due, as indicated by careful studies, to a combination of industrial wastes and sewage. However, these filtration plants consistently produce water that is free of organisms of the colon group, but the "load" on the filters has been steadily increasing from year to year.

Because of the steadily increasing sewage load in the Beaver and Shenango Rivers and the consequently increasing difficulties in the treatment of water from these sources for public purposes, it has been deemed necessary to adopt a policy looking toward reduction of the sewage load in the streams, but because of the partial reduction of the sewage load by industrial wastes in this particular stream, it has not seemed necessary to require, at this time, refined treatment of sewage discharged to the Beaver River or its tributaries in Pennsylvania, except where local stream conditions demand such treatment, but rather to require first the removal of settleable solids and to have the plans for sewage treatment works

so designed that units for further refinement in treatment may be added when conditions warrant such construction.

There are now 7 municipal sewage treatment works in operation on the Beaver River watershed in Pennsylvania and 11 other municipalities on the watershed have prepared or are preparing to construct such works in the very near future.

The Ohio State Department of Health has been coöperating informally with the Pennsylvania Department of Health toward removal of settleable solids from all sewage discharged from public sewer systems to the Beaver River or any of its tributaries above the intakes of waterworks serving the public and it is the hope that this plan of protection of the Beaver River watershed will be completely realized in the near future.

The reasons for this policy may be summarized as follows:

The communities on the lower Beaver River can be furnished only with water taken from this river, no other adequate sources of supply being available.

Modern water purification works have been able, so far, to produce consistently safe water for public use from the Beaver River, even though tastes and odors are often present and the increasing "load" on the filters is noticeable.

The necessity for protection of the watershed is evident. The elimination of all minor rural pollutions on the entire watershed would be of no practical advantage since the bulk of the sewage contamination is from public sewer systems. Refined treatment of sewage from public sewer systems would not seem justified, since industrial wastes discharged to the stream do effect some reduction of the sewage load and since these industrial wastes are so great in quantity that, even though refined sewage treatment were accomplished, the river would still not be fit for use as a source of public water supply without the most effective water purification.

The elimination of the discharge of industrial wastes to the Beaver River and its tributaries is economically impracticable, although routine investigation and control measures are effective in preventing the discharge of the more objectionable industrial wastes to the Beaver River and its tributaries.

Hence the policy: The removal of settleable solids from the sewage discharged from public sewer systems to the Beaver River or its tributaries above the intakes of waterworks serving the public, and this to be accomplished in such a manner that more refined methods of sewage treatment may be economically adopted when such additional treatment is justified.

# PROGRESS REPORT ON AGENCIES FOR THE CONTROL OF POLLUTION BY INDUSTRIAL WASTES

By Committee No. 6 on Industrial Wastes in Relation to Water Supply[1]

Your Committee on Industrial Wastes in Relation to Water Supply presents the following Progress Report on Agencies for the Control of Pollution by Industrial Wastes.

In our Progress Report of 1922, which was published in a modified form in the Journal of the Association for May, 1923, we presented information showing that more than 250 water supplies widely distributed through the United States and Canada have been injuriously affected by at least 20 different kinds of industrial wastes. The solution of water supply problems due to industrial wastes was discussed, and the need of more adequate control by state boards of health, the United States Public Health Service or other agencies, was emphasized. The present report deals with the agencies in this country and abroad, which have to do with the control of pollution by industrial wastes.

## ASPECTS OF INDUSTRIAL WASTES POLLUTION

The broad subject of pollution of waters by industrial wastes has several important aspects among which may be mentioned public health, particularly in relation to domestic water supply; public comfort, especially as regards effect on boating and bathing and conditions objectionable to sight and smell; commercial aspects, particularly as regards effect on fish and other animal life, and the use of water for industrial process purposes; and navigation, especially as regards deposits causing obstruction to shipping and the presence of objectionable substances such as acids, causing damage to vessels, and oil creating a fire hazard at the docks. Obviously industrial wastes pollution has an influence on the functions of several governmental departments, both state and national.

[1] Prepared under the direction of the Council.

STATE AUTHORITIES

Cities and towns have the responsibility of abating local nuisances and installing sewerage systems and sewage treatment works, but in matters of stream pollution the control is very largely in the hands of state authorities.

*State Boards of Health.* The control of stream pollution in the United States has been vested very largely in the state boards of health, although the replies to the questionnaire sent out by your Committee showed only five states where the authority is ample in all respects, and nearly all reported that enforcement of the laws is materially hampered by insufficient appropriation for adequate field and laboratory forces.

*State Commissions on Fisheries.* The control of stream pollution with respect to fish life has been exercised to some extent by state commissions on fisheries, or other boards having similar duties.

*State Boards of Conservation.* In some states the control of stream pollution is placed in the hands of state boards of conservation, generally with respect to effect on fish life. For example, the Conservation Commission of New York has a Bureau of Prevention of Stream Pollution, which has recently (1923) made a report on "Investigation of Pollution of Streams," authorized by the state legislature. It is interesting to note that this report recommends the establishment of a "Conservancy Commission" with general and wide powers of regulation and control of the uses of streams as affecting the quality of the water.

*Rhode Island Board of Purification of Waters.* In some states special boards have been created for the control of pollution of waters. The Rhode Island Board of Purification of Waters is an example of such a board. This board was created by Chapter 1914 of the Public Laws passed by the State Legislature in 1920. By Section 3 of this Act the Board is authorized and directed to regulate or prohibit the pollution of waters of the State in accordance with the provisions of the Act. The members of the Board are appointed by the Governor, with the advice and consent of the Senate, the term of office being one year. The Board makes annual reports to the Governor.

*Industrial Wastes Board of Connecticut.* The legislature of Connecticut in 1917 made provision for an Advisory Board to aid and assist the Department of Health in the matter of needed sewer-

age systems and refuse disposal works. Section 2562 of the Act provides as follows:

> Sec. 2562. *Assistance in Carrying out Preceding Section.* The State Department of Health, acting with five persons appointed by the governor at least two of whom shall be of recognized experience in sanitation, and at least two of whom shall be manufacturers, is authorized to make such investigations and employ such expert assistance as may be necessary to enable it to carry out the provisions of Section 2561, concerning pollution of the waters of this state. The persons so appointed shall serve without compensation. For the purposes of this section the sum of twenty-five thousand dollars is appropriated out of any money in the treasury not otherwise appropriated.

This Board adopted the title "Industrial Wastes Board," and decided to take up only the problems relating to conditions resulting from the discharge of industrial wastes, and to refer all other matters back to the State Department of Health, for disposition. The Board made reports in 1918 and 1920. It is not now in existence, but there is agitation going on looking to its renewal.

*Pennsylvania Sanitary Water Board.* The Sanitary Water Board of Pennsylvania was created by the general administrative code enacted by the 1923 Legislature for the purpose of coördinating the duties and authority of various branches of the State Government having similar purposes.

The Board consists of the Secretary of Health, who is designated as Chairman; the Secretary of Forests and Waters; the Attorney General; the Commissioner of Fisheries, and the Chairman of the Public Service Commission, and is given authority to exercise all the powers vested in the several departments relating to the pollution of streams, and which were formerly administered independently by these various state departments.

The basic legislation upon which the principal actions of the Board must rest are two in number, the first, known as the "Purity of Waters Act" enacted in 1905, to control sewage pollution of streams, for the protection of the public health, and previously administered by the Department of Health, and the second, a section of the Fisheries Code of 1917, prohibiting the discharge of substances destructive to fish. Other laws of lesser import, formerly administered by various branches of the State Government are also placed under the jurisdiction of this new Board.

The Act also provides for a study and report on methods of preventing stream pollution detrimental to public health or to animals,

fish or aquatic life, or to the use of waters for recreational purposes, and applies to all streams whether within or touching the boundaries of the State.

The Board has adopted resolutions establishing a number of fundamental policies, such as approval of former policies of the Department of Health relative to sewage discharge, the joint agreement between the States of Pennsylvania and New Jersey relative to the pollution of the Delaware River, and the joint agreement of the Departments of Health and Forests regarding camping on watersheds from which public water supplies are taken.

An important resolution which should eventually be of great value in control of stream pollution was adopted on August 8, 1923, and divides all streams of the State into three classes.

Class A streams are those in their natural state unpolluted by any artificial source, and generally fit for domestic water supply after chlorination. For this class of streams it is required that any sewage or industrial wastes originating on the watershed shall be treated to such a degree that the effluent shall be practically free from suspended matter, non-putrescent and disinfected, and that recreational use shall not be sanctioned within prejudicial influence of waterworks intakes.

Class B streams are those in which pollution is more or less existent at the present time, and where the extent of regulation, control or elimination is to be determined by consideration of the present and probable future uses of the stream, practicability of measures for abatement of pollution, and the general need for protection of the public health, animal and aquatic life, and use of the stream for recreational purposes. For this class it is proposed to determine a fixed policy for each particular stream or portion thereof after consideration of the general interests of the public and requirements of the particular case.

Class C streams are those which are now so polluted that they cannot be used as sources of public water supply, will not support fish life, and are not used for recreational purposes, and which from the standpoint of public interest, it is not necessary, economical or advisable to attempt to restore to a cleanly condition. In this class of streams, discharge of sewage and industrial wastes is permitted, provided such discharge will not create a public nuisance or menace to health.

Since its creation engineers of the Board have been correlating information in possession of the State Departments and performing additional field work to classify certain streams where there seems to be particular need of prompt action. Permits issued by the Board for the discharge of sewage or industrial wastes, or which stipulate the degree of treatment required, are in conformity with

the policies announced for respective streams, or may be taken by the public as an indication of the policy which may be set up for the particular type of stream under consideration.

In order that there may be a minimum of delay in functioning, the law delegates authority to the Department of Health to issue orders between sessions of the Board, and to take such action within the powers of the Board as the circumstances may require, but stipulates that any such order or action is subject to review by the Board at its next session.

It does not appear that this Board has great authority above that formerly possessed by individual departments, but it seems to be a forward step in that a maximum of value can now be derived through uniform administration of the numerous excellent laws upon the statute books.

"The Powers, Duties and Policies of the Sanitary Water Board of the Commonwealth" is the title of a paper by W. L. Stevenson, Chief Engineer of the Pennsylvania Department of Health, presented at the Conference on Pollution of Streams, held in Philadelphia, October 16, 1923, and published in *Engineers and Engineering*, volume XL (November, 1923), page 281.

### FEDERAL AUTHORITIES

Industrial wastes pollution is a matter of concern to several departments of the Federal government. This fact is well illustrated by the introduction in the present session of Congress of several bills relating to oil pollution, some of which are very similar, except with respect to administration, the War Department, the Department of Commerce and the Department of the Interior, being named in different bills. Furthermore, a representative of the Surgeon General of the United States Public Health Service, which is under the jurisdiction of the Treasury Department, stated at the hearings on these bills[2] that oil pollution of coastal waters has an indirect effect on health, in which the Public Health Service is interested.

*United States Public Health Service.* According to the statement of Dr. A. M. Stimson, Assistant Surgeon General,[2] the United

[2] Hearings on Pollution of Navigable Waters, before the Committee on Rivers and Harbors, House of Representatives, 68th Congress, First Session, January 23, 24, 25, 29 and 30, 1924, pp. 286-288.

States Public Health Service has authority to investigate the pollution of streams as affecting the public health, but has no administrative or control authority. During the past ten or more years the Public Health Service has made numerous investigations with respect to stream pollution, including experiments in the treatment of several industrial wastes. At the Philadelphia conference on Pollution of Streams, Dr. W. H. Frost, Surgeon of the United States Public Health Service presented a very interesting paper on "The Correlation of Sources of Pollution," published in *Engineers and Engineering*, volume XL, December, 1923, pp. 305 to 308.

*Department of Commerce.* The Department of Commerce is interested in pollution as respects fish life, through its Bureau of Fisheries, and as related to shipping, through its Bureau of Navigation. At the recent hearings before the Committee on Rivers and Harbors, Lewis Radcliffe, Deputy Commissioner of Fisheries,[3] presented information regarding the effect of oil pollution on fish life. With reference to the control of oil pollution Secretary Hoover stated[4] "that it is pretty certain that the law could be administered by the Department of Commerce through existing agencies in the Bureau of Navigation and in the Steamboat Inspection Service, with the addition of practically no officials and at only very minor expense."

*Department of the Interior.* The Bureau of Mines, of the Department of the Interior, has made an extensive investigation of petroleum oil pollution and has issued a report on the subject. Dr. F. W. Lane, Petroleum Chemist of the Bureau, discussed this subject at the recent hearings before the Committee on Rivers and Harbors.[5] He stated that the Bureau of Mines has dealt only with pollution due to petroleum oil and that the investigations were confined to the coast.

*War Department.* The War Department has jurisdiction over stream pollution from the point of view of navigation. At the Philadelphia Conference on Pollution of Streams, Colonel F. C. Boggs of the Corps of Engineers, presented a very interesting paper on "Stream Pollution as Affecting Navigation[6] in which the laws bearing on the subject are explained. He divides industrial wastes

[3] Ibid., pp. 24–27.
[4] Ibid., p. 10.
[5] Ibid., pp. 17–23 and 218–221.
[6] *Engineers and Engineering*, vol. XL, February, 1924, pp. 40–46.

as related to navigation, into two general classes,—first, solids, which may actually impede vessels or which by their deposition in navigable channels may form obstructions; and second, semi-solids, or liquids, which may be injurious to navigation interests either by their chemical attack on shipping facilities or by their menace to such facilities from some other cause, as for example fire. The administration of the laws lies with the Secretary of War and Chief of Engineers, through the Division Engineer and District Engineer of the district in which the pollution occurs. At the recent hearings on pollution of navigable waters Major General Lansing H. Beach, Chief of Engineers[7] presented information regarding pollution particularly with respect to acid wastes.

*Provision for Control of Pollution in New York Harbor.* Although the control of pollution of navigable waters is vested in the War Department, there is on the statute books the Act of June 29, 1888, amended by the Act of August 18, 1894, for the prevention of pollution in New York Harbor, which is independent of the War Department. This Act deals with pollution not only by the waste matters referred to in the general River and Harbor Act, but also with respect to oil and oil wastes, and under this Act the supervision of New York Harbor is placed in the hands of the Supervisor of the Port of New York and a naval officer is detailed for this particular work, and the expenses of this supervision are covered by special congressional appropriations. The present Supervisor of New York Harbor, Capt. J. C. Freemont, United States Navy, made a statement regarding the oil pollution situation at the recent hearings before the Committee on Rivers and Harbors.[8]

## JOINT UNDERTAKINGS ALONG SANITARY LINES, WITHIN SEPARATE STATES

The multiplicity of interests affected by industrial wastes pollution demonstrates the need for joint undertakings for the solution of problems resulting therefrom. There has been a considerable number of such joint undertakings within individual states in this country.

[7] Hearings on Pollution of Navigable Waters, before the Committee on Rivers and Harbors, House of Representatives, 68th Congress, First Session, January 23, 24, 25, 29 and 30, 1924, pp. 271–284.

[8] Ibid., pp. 37–40.

*Provision for Sanitary Districts.* In order to facilitate common interests in sanitary matters such as water supply and sewage disposal, laws making provision for sanitary districts comprising two or more municipalities have been passed in several states. Among these may be cited the laws making provision for Sanitary districts in the State of Indiana. The Act (Chapter 307 of the General Laws of Indiana, 1913) as amended (Chapter 11 of the General Laws, 1919) provides that two or more incorporated municipalities in any one country may form a sanitary district upon petition of 500 legal voters and a majority vote passed by each municipality in an election held for the purpose. The Act provides for the construction of sewerage works and works for the disposal of garbage and refuse, the issuing of bonds and the levying of taxes. The issuing of bonds is limited to 2 per cent of the valuation, and the rate of interest is not to exceed 5 per cent. The tax levy is not to exceed 0.25 per cent of the valuation of the taxable property. The administration of the law is placed in the hands of 5 trustees appointed by the Judge of the Circuit Court of the county in which the district is located, and receiving a salary of $500 each.

A paper on "Organization of Metropolitan Districts," by Langdon Pearse, was presented before the American Society for Municipal Improvements in 1921, and was published in the Proceedings of the Society for that year. A few examples of such organizations are described below.

*Metropolitan District Commission in Massachusetts.* One of the earliest sanitary district organizations was the Metropolitan Sewerage Board in Massachusetts, serving Boston and the Metropolitan area thereabout, formed in 1889. In 1895 a Metropolitan Water Board was formed, and in 1901 these two boards were consolidated into the Metropolitan Water and Sewerage Board. In 1919 provision was made for the formation of the Metropolitan District Commission (Chapter 350, General Acts of 1919), whereby the Metropolitan Water and Sewerage Board and the Metropolitan Park Commission were consolidated.

The Metropolitan District Commission consists of one commissioner and four associate commissioners, appointed by the Governor, with the advice and consent of the Council, for a term of five years. The Commissioner receives an annual salary not to exceed $6000, and the associate commissioners not over $1000 each. The Commission is organized with Water, Sewerage and Park divisions, each having the necessary engineering, clerical and police force. The districts served by these divisions are not coextensive. Although administered by the same board, each division has a separate organization. The expenses of the maintenance of the divisions are kept separately, and the

salaries of the commissioners and general office expenses are apportioned among the divisions. The appropriations are made by the State Legislature, and the moneys are handled by the State Treasurer, who assesses the expense against the various cities and towns in accordance with the terms of the legislative act.

*The Sanitary District of Chicago.* The Sanitary District of Chicago is described by Langdon Pearse, Chief Engineer of the District, as follows:

"Operative under the Act of May 29, 1889. The original act of May 29, 1889, has been amended in various years, both to extend the powers of the District and to cure various defects found, as well as to provide for annexation of additional areas. While originally drawn as a general act, it has been adopted alone by the Sanitary District of Chicago. Powers are granted by the charter to build channels, drains and docks, dispose of water power, and by the most recent amendment specific power to construct intercepting sewers, pumping stations and sewage treatment works. The district at present comprises some 45 municipalities, including the city of Chicago. For the purpose of administration, a board of nine members is provided, three of whom are elected every two years, and one of whom is chosen by the Board to act as presiding officer. The funds for the work are provided by the issuing of bonds, in amounts not to exceed 3 per cent of the assessed valuation. For operating expenses, payment of interest and the like, provision is made for a taxing power not to exceed ¾ per cent of the assessed valuation. The most recent amendment provides for a minimum levy of 1.2 mills on the dollar. The area served at present is 395.51 square miles, and includes all of Chicago and 45 incorporated cities and villages." (*Proc. of the Amer. Soc. for Munic. Improvements*, 1921 Convention, pp. 109–125.)

*Passaic Valley Sewerage Commission.* Chapter 10 of the New Jersey Laws of 1907 provides for purification of the waters of the Passaic River within the Passaic Valley Sewerage District from the Great Falls in Paterson to the mouth of the Passaic River in Newark Bay. The Passaic Valley Sewerage Commission of five members, appointed by the Governor, each for a term of five years, has complete jurisdiction over this project so far as the state is concerned.

This act fixes a date when every municipality, corporation and individual is prohibited from discharging polluting matter into the Passaic River within the limits of the district. The Commission is authorized to institute suits at law or in equity to enforce this provision and the Court of Chancery is also vested with special jurisdiction in respect to such enforcement. Municipalities may provide separate adequate purification arrangements or they may enter into a joint undertaking as provided for in the Act. The Commission has authority to contract with municipalities for the construction of intercepting sewers and disposal works for the disposal of polluting matters including not more than 10 per cent of the factory wastes excluding gas works wastes and other substances which may injuriously affect the integrity of the sewers. Such contracts with municipalities stipulate a capacity which each municipality is to have in the joint works but a municipality may contract for more than its prorated share by meeting the expense of any such requisition. The construction cost is to be apportioned among the contracting

municipalities in proportion to their taxable property. Funds in addition to those provided in the initial contract and required for the works as a whole, are procurable only through supplementary contracts between the Commission and all contracting municipalities. Under the State Constitution the state cannot issue bonds for such an undertaking. The contracting municipalities are authorized to issue bonds for this purpose up to 5 per cent of their tax ratables in addition to the established bonding limit for other purposes.

The cost of operation and maintenance of these works, expected to go in service in the early summer of 1924, is to be raised by the contracting municipalities by taxation, and prorated according to the volume of sewage and wastes contributed by each.

*Joint Meeting of the Inhabitants of the City of Plainfield, the Borough of North Plainfield and the Borough of Dunellen.* Chapter 112 of the New Jersey Laws of 1910 authorizes any two or more municipalities in the state to jointly provide and operate outlet sewers and sewage disposal plants. This is the basis on which Madison and Chatham and also Plainfield, North Plainfield and Dunellen have proceeded. The sewage of the three last named places is treated at Green Brook Park. This act provides that municipalities desiring to establish joint works shall first prepare an adequate preliminary report of the undertaking with estimates of cost of construction and operation. This report, made at joint expense, must be acceptable to the authorities of each municipality and to the State Board of Health. The inhabitants of the municipalities must vote on means of financing the project by assessment or the issue of bonds as may be decided upon.

After an affirmative vote of the municipalities there is set up a "Joint Meeting" composed of members of the municipal government of the interested parties and such other members as may be respectively decided upon. This Joint Meeting thenceforth proceeds with officers and committees and employees in substantially the same manner as would individual municipalities. Each municipality on request from the Joint Meeting provides its established share of the cost of construction. Expense of operation and maintenance is in accordance with agreements in the contract between the municipalities and in some instances is based on the respective volumes of sewage flow and in other instances on the number of sewer connections. Joint Meetings authorize and approve a budget of expense, the contributions to which are generally made to the Joint Meeting for disbursement through its officers.

*Joint Undertakings in California.* In California, Pasadena, South Pasadena and Alhambra for a great many years have been disposing of their sewages by a mutual contract. They are now constructing an activated sludge plant on the same basis, each city having voted bonds for an agreed amount, and arrangement is made whereby Pasadena, for certain payment, assumes all responsibility for the treatment. A similar working agreement exists between the towns of Santa Ana, Anaheim, Orange and Fullerton. In this case the work is the construction of a long outfall to the ocean and a screening plant. Santa Ana assumes the responsibility for the operation of the plant.

Los Angeles is entering into contracts with cities round about for carrying their sewage to the ocean and screening it. The last legislature passed a

bill called the "County Sanitation District Act" which has for its express purpose the building of trunk line sewers to serve several cities and even unincorporated territory, but the bill also provides that such a District may by arrangement take over all or part of the local sewer system and treatment works. One District has been formed in the southern part of the state, called the South Coast Metropolitan Sewer District, comprising Manhattan, Hermosa Beach, Redondo Beach and Palos Verde. Another District is being agitated, called the Central Metropolitan District, which would provide for Compton, Watts, Whittier, and a great many still smaller communities. This act has not been submitted to the Courts, but undoubtedly it will be reviewed by them before any of the Districts finally complete their plans.

There is also another act called the "City Boundary Extension Act" passed by the last legislature, which enables several cities and county territory to construct sewage works, using one of the favored improvements acts. This act, however, does not provide for maintenance and until this is provided, the item must be covered by mutual contribution of the cities and territory affected.

### EUROPEAN BOARDS FOR THE CONTROL OF STREAM POLLUTON

There appears to be no general provision in this country for joint undertakings with respect to the control of stream pollution by two or more states, although there have been mutual agreements between different states, notably that of Pennsylvania and New Jersey, which provides a uniform policy as to the degree of treatment of sewage, required prior to discharge into Delaware River, adopted by the departments of health of the two states in 1922.

In Great Britain and in Germany there are a number of boards having jurisdiction over whole watersheds. These boards are referred to in a paper on "Government Control of Pollution," by C. A. Emerson, presented at the Philadelphia Convention on Pollution of Streams and published in *Engineers and Engineering*, volume XLI, January, 1924, pp. 11–13. Additional information is given by George W. Fuller in his discussion of this paper.

*Provision for Rivers Boards in Great Britain.* From the Interim Report of the Royal Commission on Sewage Disposal, 1901, volume I, page xi, it appears that, on account of the fact that the Rivers Pollution Prevention Act, of 1876 had not resulted in the general purification of the rivers, due largely to the reluctance of each local authority to put the Act in force, without assurance that other local authorities on the stream would do likewise, but partly to the difficulty in proving that the pollution complained of was the result of discharge within that particular district, a Local Government

Act was passed in 1888, authorizing the county councils of England and Wales and Scotland to enforce the provisions of the Rivers Pollution Prevention Act, in relation to the portions of any stream within their counties, and specifying that "The Local Government Board by Provisional Order made on the application of the Council of any of the counties concerned, may constitute a Joint Committee or other body, representing all the administrative counties, through or by which a river or any specified portion of a river or any tributary thereof passes, and may confer on such committee or body all the powers of a sanitary authority, under the Rivers Pollution Prevention Act, 1876, or such of them as may be specified in the Order." Under this act three rivers were constituted:

The Mersey and Irwell Joint Committee
The Ribble Joint Committee
The West Riding of Yorkshire Rivers Board

These boards comprise from 20 to 30 men elected by the councils of the component municipalities, from among their own membership. Representation on the Board is proportionate to the size of each municipality, and operating expenses are provided from funds collected from the various municipalities. The actions of these boards, in carrying out the general pollution laws, are to a large extent independent of the Ministry of Health in London, which was recently formed to take over the functions of the Local Government Board; but in the case of such matters as bond issues or legal action against a manufacturer the consent of the Ministry of Health must previously be obtained.

*The Mersey and Irwell Joint Committee.* The Mersey and Irwell Joint Committee was formed in 1891 and has jurisdiction over a portion of the watersheds of the Mersey and Irwell Rivers, including the county boroughs of Bolton, Bury, Manchester, Oldham, Rochdale, Salford and Stockport. According to the testimony of R. A. Tatton, before the Royal Commission on Sewage Disposal, Interim Report, 1902, volume II, the Mersey and Irwell rivers were badly polluted and the construction of the Manchester Ship Canal, in which the waters of Irwell River were impounded, made some action necessary. In 1889 a conference of sanitary authorities was held and an appeal made to the county councils of Lancashire and Cheshire, which in turn applied to the Local Government Board. The outcome was a provisional order of the Local Government Board, constituting the Joint Committee of the rivers Mersey and Irwell.

The first meeting was held at Manchester, October 5, 1891. The early work was confined to prevention of pollution by solids. A survey was made of sources of sewage and trade wastes pollution. On December 7, 1891, a bill for further powers was introduced, which was supported by the manufacturers, who felt that they would benefit by improved water courses. In 1892 the Committee applied for still further power, and this was granted. The Committee decided to adopt no fixed standard of pollution.

*The Ribble Joint Committee.* The Ribble Joint Committee was formed in 1891, and has jurisdiction over portions of the watersheds of the River Ribble, and certain other streams, including the county boroughs of Blackburn, Burnley, Preston and Wigan. According to the testimony of William Naylor, before the Royal Commission, Interim Report, volume II, 1902, the Ribble Joint Committee held meetings monthly, presenting a report each month and annual reports in 1897 and 1898.

In 1893 Mr. Naylor presented to the Committee a special report, which was followed by a conference with manufacturers, with respect to the treatment works desirable for them to install. Agreements were drawn up with the different trades, but in the case of the paper trade no general agreement was arrived at and the Committee dealt with each case separately.

*The West Riding of Yorkshire Rivers Board.* The West Riding of Yorkshire Rivers Board was formed in 1893, and has jurisdiction over the rivers in the county boroughs of Bradford, Halifax, Huddersfield, Leeds and Sheffield, which constitute an important industrial district. According to the testimony of Trevor Edwards, before the Royal Commission, Interim Report, volume II, 1902, this Committee consists of 30 members elected from 6 counties. In addition to the powers of a sanitary authority under the Rivers Pollution Prevention Acts, the Board has additional powers under "The West Riding of Yorkshire Rivers Act of 1894." The magistrates are the tribunal under this act.

*Advantages of Rivers Boards.* The Royal Commission, in its third report, 1903, states that these rivers boards are of much greater value for the protection of rivers and streams than the separate councils acting independently, and that, although some of those against whom action has been taken by these boards, have complained, as might be expected, generally speaking both the local authorities and the manufacturers recognize that in this way ef-

fective action is taken for the improvement of the rivers in their districts. The evidence before the Royal Commission on Sewage Disposal shows that these boards have accomplished much useful work in cleaning up the rivers.

We are informed that about the middle of April, 1923, a conference was held, respecting the formation of a new rivers board for the Valley of the Trent, but we have not yet learned whether such a board has been formed.

*Other Boards in Great Britain.* Other boards having similar functions have been created by special acts. The Thames Conservancy Board has control of the upper reaches of the River Thames, from which the London Water supply is taken. The tidal portion of the river, below Teddington Weir, is under the jurisdiction of the Port of London Authority.

*Emscher District in Germany.*[9] In Germany there are various river or drainage districts, of which the Emscher District in the industrial area of western Germany is a noteworthy example. In 1902, following an order by the Prussian government, requiring the construction of sewerage works in the district, a number of municipalities and large industries in the district, formed an association and employed experts to determine what action should be taken. The Chief Engineer's report, completed in 1904, described existing conditions, outlined a plan for improvement, and suggested the passage of a law appointing a Board of Control for the district, with very broad powers, including authority first, to compel cities and towns to construct and maintain suitable sewerage systems for the removal of house sewage and liquid manufacturing wastes, preliminary treatment of the latter being required where necessary; second, to design, construct, maintain and operate, sewage disposal works to be used by two or more municipalities, and to deepen, enlarge, or change the course of the main stream and such tributaries as might require changes to insure satisfactory drainage of the entire area.

In 1906 the Prussian government passed a law granting substantially the authority requested to a Board made up of more than 100 members, representing the state, county, city, farm, mine, and industrial interests.

The Emscher District is not coincident with any political division, but includes the entire drainage area of the Emscher River, repre-

[9] Information from Article by Charles M. Saville in Eng. News, December 1, 1910.

senting an area of approximately 308 square miles. The Board, or General Assembly, meets usually once a year, the actual work being carried on by a Board of Directors, 10 in number, The law requires that at least 3 of the directors must be representatives of the state. The others are chosen from among the mayors of the larger cities, and officials of the more important industries in the district. Another body, acting as a Board of Appeals, is also elected by the General Assembly, and the law requires that a certain number of the members be representatives of the state. The Board of Directors employs an engineering force, and has general supervision over the design, construction, and operation, of the engineering works. It submits a budget annually to the General Assembly, and upon approval, raises money by the issue of bonds, and it has charge of all expenditures. The cost of improvements is charged against the cities, land, mine, and industrial interests, the assessments being determined each year by the Board of Directors on the basis of responsibility for the objectionable conditions to be eliminated, and the improvements derived. In case the assessments appear to be unjust, the matter must be submitted to the Board of Appeals, whose decision is final. The General Assembly, under the law, may exercise the right of eminent domain, and take any land necessary for carrying out its work, disagreements concerning the value of the property taken being settled in the courts.

### INTERNATIONAL ASPECTS

The problem of pollution of waters has its international aspects. *International Joint Commission of the United States and Canada:*

Under the terms of Article IX of the treaty of January 11, 1909, between the United States and Great Britain, the Governments of the United States and of the Dominion of Canada jointly referred to the International Joint Commission for examination and report, with such conclusions and recommendations as might seem appropriate, the following questions:

(1) To what extent and by what causes and in what localities have the boundary waters between the United States and Canada been polluted so as to be injurious to the public health and unfit for domestic or other uses?

(2) In what way or manner, whether by the construction and operation of suitable drainage canals or plants at convenient points or otherwise, is it possible and advisable to remedy or prevent the pollution of these waters, and by what means or arrangement can the proper construction or operation of remedial or preventive works, or a system or method of rendering these waters sanitary and suitable for domestic and other uses be best secured and

maintained in order to insure the adequate protection and development of all interests involved on both sides of the boundary, and to fulfil the obligations undertaken in Article IV of the waterways treaty of January 11, 1909, between the United States and Great Britain, in which it is agreed that the waters therein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other? (Progress Report of the International Joint Commission, January 16, 1914, p. 3.)

This Commission, with the aid of sanitary experts, made extensive investigations. A voluminous progress report was presented on January 16, 1914, and a Final Report, with conclusions and recommendations, on August 12, 1918. The final recommendation was as follows:

In order to remedy and prevent the pollution of boundary waters and to render them sanitary and suitable for domestic purposes and other uses, and to secure adequate protection and development of all interests involved on both sides of the boundary, and to fulfill the obligations undertaken in Article IV of the treaty, it is advisable to confer upon the International Joint Commission ample jurisdiction to regulate and prohibit this pollution of boundary waters and waters crossing the boundary. (Final Report of the International Joint Commission, p. 52.)

So far as we are informed this Joint Commission is still in existence.

*Conference of Maritime Nations, on Oil Pollution.* By a joint resolution of Congress, approved July 1, 1922, the President was "authorized and requested to call a conference of maritime nations with a view to the adoption of effective means for the prevention of pollution of navigable waters, by oil-burning and oil-carrying steamers, by the dumping into such waters of oil waste, fuel-oil, oil sludge, oil slop, tar residue and water ballast." Following the passage of this resolution a Joint Committee of the Department of Commerce, the Department of the Interior and other departments, was formed, to study the question. Secretary Hoover stated at the hearings before the Committee on Rivers and Harbors[10] that there has been a good deal of discussion with the British, regarding the preliminaries of such a conference, and that the International Conference will probably be held at an early date.

[10] Hearings on Pollution of Navigable Waters, before the Committee on Rivers and Harbors, House of Representatives, 68th Congress, First Session, January 23, 24, 25, 29 and 30, 1924, p. 11.

## CONFERENCES ON INDUSTRIAL WASTES POLLUTION

The pollution of waters by industrial wastes has become very acute in different parts of this country and ways and means must be found for solving the problems created thereby. Such problems can be solved only by coöperative effort of all interested parties. Several important conferences on industrial wastes pollution have been held recently which should be referred to in this report.

*Philadelphia Conference on Pollution of Streams.* Under the auspices of the Engineers' Club of Philadelphia, a conference on Pollution of Streams Especially with Reference to Pollution due to Industrial Wastes, was held in Philadelphia on October 16, 1923. To this conference were invited representatives from National, State and City Governments, from various societies and from the industries themselves. Papers presenting different aspects of the subject were read and discussed. These papers which are being published in *Engineers and Engineering*, the journal of the Philadelphia Engineers' Club, have constituted one of the sources of information for this report. The work of your Committee on Industrial Wastes in Relation to Water Supply was described in a paper by the Chairman.

*Conferences on Phenol Wastes.* The serious and widespread troubles from tastes and odors imparted to water supplies by the so-called phenol wastes from gas and by-product coke manufacturing, led the Surgeon-General of the United States Public Health Service to call together, for a conference on this subject, the various representatives of the States and Health Organizations, where complaints of this kind of pollution have originated. The final result of this conference was the adoption of a resolution requesting the United States Public Health Service to further investigate this problem with respect to its public health aspects, and the Bureau of Mines to investigate it in its industrial aspects, that is, particularly in regard to practical methods of eliminating or treating the wastes at their sources.

Surgeon W. H. Frost of the United States Public Health Service has been in communication with the Chairman of your Committee on Industrial Wastes in Relation to Water Supply and has been furnished the detailed information on this subject collected by the Committee. Mr. H. R. Crohurst, Sanitary Engineer, has been assigned to make the investigation for the Public Health Service,

and, at Dr. Frost's request, the Chairman of your Committee held a conference with Mr. Crohurst in relation to the scope and methods of his investigations.

In a statement made at the Hearings on the Pollution of Navigable Waters, before the Committee on Rivers and Harbors in January, 1924, Dr. A. M. Stimson, Assistant Surgeon General of the United States Public Health Service[11] refers to a second conference held that week at which representatives of all of the Ohio River states with the exception of Indiana and Illinois were present. He states that in the absence of existing legislation of a Federal nature, the health officials and engineers attached to the Health Departments have organized themselves into an informal committee for the purpose of securing what can be done locally by interstate agreement, believing that they should exhaust the possibilities of such agreement and learn by experience what the methods of prevention are before calling for specific aid in the way of Federal Legislation.

A permanent organization has been effected with Dr. Monger of Ohio, President, and Mr. Tisdale, of West Virginia, as Secretary. The objects of this organization, as expressed in the Resolutions adopted, include the establishing by the states interested of a standard policy of administrative control and uniform policy of action to secure correction of the damage to public water supplies caused by coke plants and other industries producing taste-causing wastes.

*National Coast Antipollution League.* Because of the serious and widespread pollution of coastal waters of the United States, the National Coast Antipollution League was formed in 1922. David M. Neuberger, President of the League, stated at the hearings on the Pollution of Navigable Waters before the Committee on Rivers and Harbors,[12] that the Antipollution League came into existence as a result of an interstate committee for the prevention of pollution of the coastal waters of New York and New Jersey, and of a call which was made by the State League of New Jersey Municipalities, upon the Atlantic Coast municipalities of the United States for a conference and formation of a permanent body to be organized to obtain the enactment of Federal and State Laws to prevent further pollution of coastal and inland waters.

[11] Ibid., pp. 286–288.
[12] Ibid., pp. 56–65.

A Conference on Pollution called by the League, was held at Atlantic City on October 2 and 3, 1923, and a Committee was appointed to confer upon the proposed legislation. The League has been active in the legislation now before Congress.

## LEGISLATION

The tendency of legislation with respect to pollution of waters by industrial wastes, is shown by the bills introduced in the present session of Congress.

*S-42.* Among the bills introduced in the Senate, and considered at a hearing before a sub-committee of the Committee on Commerce, January 9, 1924, S-42 which is the most drastic, makes it unlawful to discharge from any ship or from any land plant, oil in any form, or any refuse matter of any kind other than ordinary sewage, into any navigable water of the United States, or into any tributary of any navigable water, or the deposition of solids on the banks where it may be washed into such navigable waters. The Secretary of War is charged with the administration, the maximum penalty being a fine of $1500 or imprisonment for one year, or both, and the minimum penalty a fine of $500, or imprisonment for thirty days, or both, one-half of said fine to be paid to the informant.

*S-936.* Another bill, S-936, is similar to S-42, except that it refers only to oil in any form and not to other refuse.

*S-1388.* A third bill, S-1388, is similar to S-936, except that in respect to non-navigable waters it applies only to those connecting navigable waters, and no minimum penalty is set, the maximum being a fine of $2500 or imprisonment for one year, or both.

*S-1942.* The bill which has passed the Senate, S-1942, makes it unlawful to discharge oil of any kind from ships or from land plants, into coastal navigable waters of the United States (waters in which tide ebbs and flows), but the Secretary of War is authorized to make regulations under which such quantities as shall not be deleterious to health or fish, or dangerous to property, may be permitted. The maximum penalty is a fine of $2500 or imprisonment for one year or both, and the minimum penalty is a fine of $50.

*Bills Referred to Committee on Rivers and Harbors.* Among the bills referred to the Committee on Rivers and Harbors, and considered at the hearings on January 23, 24, 25, 29 and 30, 1924, there are counterparts of the Senate bills already described. The other bills having special features are described below.

*HR-612.* This bill applies only to oil pollution by ships, of waters navigable in fact, in which the tide ebbs and flows. The only penalty is a maximum fine of $2500. The administration of the bill is placed in the hands of the Secretary of Commerce, who is empowered to prescribe rules and regulations permitting the discharge of oil under restrictions and to mitigate or remit any penalty. This bill also makes provision for investigations by the Secretary of Commerce, of all sources of pollution affecting navigation. Section 11 of the bill is as follows:

> That the Secretary is authorized and directed to make such investigation as may be necessary to ascertain what polluting substances, the sources thereof, and by what means they are deposited into any of the navigable waters of the United States, including non-navigable waters connecting navigable waters, to such an extent as to endanger or interfere with navigation or commerce upon such waters, or the fisheries therein. The Secretary shall report the results of his investigation to the Congress not later than two years after the passage of this act, together with such recommendations for remedial legislation as he deems advisable.

*HR-51.* This bill is similar to HR-612, except that the administration is placed in the hands of the Secretary of War, with no provision for investigations, and the maximum penalty is a fine of $2500, or imprisonment for one year, or both. Provision is also made for suspension of the act, by the President, in time of War.

*HR-690.* This act prohibits the discharge of free acid or acid wastes including mine drainage, into any navigable water or tributary thereof, the maximum penalty being a fine of $2500, or imprisonment for one year, or both, and the minimum a fine of $500 or imprisonment for one year, or both. The Secretary of War is empowered to make rules and regulations. The control is placed in the hands of the Chief of Engineers, who is directed to consult and advise with the owners as to the best practicable and reasonably available means of making such waste harmless.

*HR-6256.* This act prohibits the discharge of oil from an oil well, terminal, refinery, tank or place of storage, into any navigable river or tributary thereof, with a maximum penalty of a fine of $2500 or imprisonment for one year, and a minimum penalty of $50 fine. The Secretary of the Interior is charged with the administration of this bill and authorized to prescribe regulations.

*Prospective Legislation.* According to the latest information received, none of these bills has yet passed the House of Representatives, but we are informed on good authority that legislation will

probably be enacted by the House, based on HR-612, and S-1942, already passed by the Senate.

*Recent British Legislation.* In addition to an act for the protection of waters containing fish, from poisonous matter and trade effluents (Salmon and Fresh Water Fisheries Act, 1923, Part I, Section 8), the British have recently passed very drastic laws bearing on oil pollution ("An Act to make Provision against the Discharge or Escape of Oil into Navigable Waters, enacted in 1923"). This Act applies both to vessels and to places on land. The penalty is a fine not exceeding 100 pounds, which is equivalent to approximately $500. As it appeared impracticable to compel the installation of separating apparatus on any but the largest ships, provision was made for barge service in certain harbors, to collect the oil ballast.

*Injunction Decision, City of McKeesport vs. Carnegie Steel Company*

On September 16, 1918, the City of McKeesport filed a bill to restrain the Carnegie Steel Company from polluting the Monongahela River by discharging therein waste fluid from its by-product plant at Clanton, Allegheny County, Penna. A hearing on the motion for a preliminary injunction by the plaintiff, the City of McKeesport, was held on September 20, 1918. The testimony showed that the public water supply of the City of McKeesport was adversely affected by the discharge of waste by-product from the Clairton plant into Peters Creek, which empties into the Monongahela River, one of the sources of water supply for the City of McKeesport. The preliminary injunction was granted to the plaintiff. (No. 1647, October Term, 1918, Docket "C".) (Opinion by Justice Brown, filed September 27, 1918.)

*Need of Sound Legislation.* State legislation is needed in some states, to control adequately industrial wastes pollution within these states. National legislation is needed, to control pollution of interstate and coastal waters. Such legislation, whether state or national, must be considered from the broad viewpoint of public welfare. It should be based on the results of thorough investigation. The importance of securing the coöperation of all interested parties, must not be lost sight of.

Respectfully submitted,

A. L. Fales, *Chairman,*
Wellington Donaldson,
C. A. Emerson, Jr.,
L. A. Geupel,
C. G. Gillespie,
Harry B. Hommon,
F. W. Mohlman,
James A. Newlands.

# THE ACTION OF WATER ON SERVICE PIPES[1]

By Wellington Donaldson[2]

Delivery of water from street mains to faucets of the consumers without impairment of the quality of water or without deterioration of the service pipe itself has been a problem since the earliest days of water supply. The great diversity in physical and chemical properties of water has resulted in the use of various pipe materials which experience has found most suitable for a given locality. There is no "one-best" pipe applicable to all conditions, taking into account the elements of quality of water and cost of installation and maintenance.

## EXTENT OF USE OF VARIOUS KINDS OF SERVICE PIPE

Comprehensive statistics in regard to various kinds of service pipes are not available to the committee at this time, but attention is called to an interesting recent tabulation prepared by the editor of Public Works based on a questionnaire sent to about 800 cities in all parts of the United States (1), some results of which are summarized in table 1.

The figures cited, although useful in indicating the trend of practice, nevertheless must be taken with reservations because they cover only a small portion of the total works in this country. The number of cities reported on from the different states is quite disproportionate, as the list includes 50 plants in Massachusetts, and only one each in New Hampshire, New Jersey and Utah. The omission of cities of the first rank is notably conspicuous. For instance, the tabulation does not include any of the large cities in New York State and omits such important cities as Philadelphia, Pittsburgh, Cleveland, Cincinnati, Chicago, New Orleans, Birmingham, Memphis, Kansas City, Dallas, San Francisco, Los Angeles, etc.

[1] Contribution to work of Committee No. 10 on Standardization of Services, J. M. Diven, chairman.

[2] With Fuller and McClintock, New York, N. Y.

TABLE 1

*Relative use of various service pipe materials for 539 cities of United States*

| STATE OR PROVINCE | NUMBER OF CITIES LISTED | NUMBER CITIES HAVING SERVICE PIPE OF | | | | | |
|---|---|---|---|---|---|---|---|
| | | Galvanized wrought iron or steel | Lead | Cast iron | Lead lined | Cement lined | Wrought iron or steel* |
| Alabama | 8 | 7 | 1 | 1 | | 1 | |
| Arizona | 7 | 5 | 3 | | | | 3 |
| Arkansas | 9 | 6 | 1 | 1 | | | 1 |
| California | 29 | 10 | 2 | 2 | | | 20 |
| Colorado | 11 | 2 | 6 | | | | 5 |
| Connecticut | 10 | 5 | 4 | | 1 | | 5 |
| Florida | 9 | 2 | 5 | 1 | | | 4 |
| Georgia | 15 | 5 | 3 | | 1 | 1 | 10 |
| Idaho | 9 | 8 | 1 | | | | |
| Illinois | 37 | 8 | 30 | 3 | | | 14 |
| Indiana | 44 | 11 | 25 | 2 | 1 | | 13 |
| Iowa | 29 | 5 | 25 | 2 | 1 | | 13 |
| Kansas | 26 | 8 | 16 | 3 | | | 18 |
| Kentucky | 13 | 7 | 7 | | | | 3 |
| Louisiana | 4 | 1 | 1 | | | | 2 |
| Maine | 9 | 4 | | | 2 | 1 | 6 |
| Maryland | 2 | 1 | | | 2 | | 1 |
| Massachusetts | 50 | 12 | 10 | 5 | 8 | 24 | 22 |
| Michigan | 37 | 10 | 16 | 2 | | | 14 |
| Minnesota | 27 | 7 | 16 | 2 | | | 9 |
| Mississippi | 12 | 3 | 8 | | | 1 | 9 |
| Missouri | 12 | 2 | 9 | 1 | | | 7 |
| Montana | 9 | 6 | 8 | 1 | | | 1 |
| New Hampshire | 1 | | | | | 1 | |
| New Jersey | 1 | 1 | 1 | | | | 1 |
| New Mexico | 2 | 2 | | | | | |
| New York | 7 | 1 | 4 | | | | 4 |
| North Carolina | 5 | 2 | | | | | 4 |
| North Dakota | 3 | | 3 | 1 | | | |
| Ohio | 22 | 6 | 14 | | | | 8 |
| Oklahoma | 14 | 3 | 10 | 1 | | | 6 |
| Oregon | 7 | 5 | | | | | 1 |
| Pennsylvania | 14 | 3 | 7 | | | | 10 |
| Rhode Island | 3 | 1 | 2 | | | | |
| South Carolina | 2 | 2 | | | | | |
| South Dakota | 3 | | 3 | | | | |
| Tennessee | 6 | 2 | 5 | | | | 2 |
| Texas | 16 | 2 | 10 | 3 | | | 9 |
| Utah | 1 | 1 | | | | | |
| Vermont | 2 | | 1 | | | | 1 |
| Washingron | 12 | 9 | 2 | | | | 3 |
| Total | 539 | 175 | 259 | 31 | 16 | 29 | 229 |
| Per cent of total | | 32 | 48 | 5.7 | 3 | 5.4 | 42 |

*Coating not stated.

The last column of table 1 evidently arises from a lack of explicitness on the part of cities responding to the questionnaire. The use of "black" or ungalvanized wrought iron and steel pipe for water services is believed to be insignificant, therefore the last column should be included under "galvanized," which would indicate a predominance of galvanized pipe for services, as is believed to be true for the country at large. The use of cast iron for services evidently is limited to sizes of 1½-inch and over, more generally 4-, 6-, and 8-inch factory connections, and therefore negligible for ordinary domestic use.

TABLE 2

*Additional data on service pipe material for 42 cities, mostly in Massachusetts*

| STATE OR PROVINCE | NUMBER OF CITIES LISTED | NUMBER USING SERVICE PIPE OF | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Galvanized wrought iron or steel | Lead | Cast iron | Lead lined | Tin lined | Cement lined | Coated* wrought iron |
| Massachusetts | 27 | 12 | 15 | 13 | 10 | 4 | 16 | 14 |
| Vermont | 1 | 1 | 1 | 1 | | | | |
| New Hampshire | 2 | 1 | 1 | 1 | | | 1 | 1 |
| Rhode Island | 2 | | 2 | 1 | | | | 1 |
| Michigan | 1 | 1 | 1 | 1 | | | | |
| New Jersey | 1 | | 1 | 1 | | | | 1 |
| Pennsylvania | 2 | 1 | 2 | 1 | 1 | | | 1 |
| Wisconsin | 1 | | 1 | | | | | |
| Oregon | 1 | 1 | | | | | | |
| Kentucky | 1 | 1 | 1 | | | | | |
| Connecticut | 1 | 1 | 1 | | | | 1 | |
| Ontario | 2 | 1 | 2 | 1 | | | | |
| Total | 42 | 20 | 28 | 20 | 11 | 4 | 18 | 18 |
| Per cent of total | | 47 | 67 | 47 | 26 | 9.5 | 43 | 43 |

*Note:* Holyoke, Massachusetts, uses some rubber lined pipe. *Includes "enamelled" and "tar coated."

Where services are laid in advance of new pavement a decided preference is indicated by the Public Works questionnaire for lead piping.

The New England Water Works Association has published certain statistics (2) comprising 36 New England cities and 9 cities elsewhere in United States and Canada. Data regarding service pipe are summarized in table 2.

## LIFE OF SERVICE PIPE

The Public Works questionnaire, already referred to, included data as to life of various service pipe materials, but the results are of uncertain value, as they are obviously "judgment" figures and not based on actual records of service pipe replacement. Covering practically the same cities comprised in table 1, it was shown, in general, that galvanized pipe had a life of from one to thirty-five years, while the life of lead pipe was given as four years to "indefinite." The life of lead-lined pipe was reported as twelve to thirty-five years in the states of Indiana, Maryland and Massachusetts. The life of cement-lined pipe in Maine is reported as fifty years, in Massachusetts from ten to fifty years and in New Hampshire from twenty-five to thirty-five years.

The behavior of various kinds of service pipe, in so far as it relates to action of water on interior surfaces, and not to destruction by electrolysis, outside soil corrosion, or mechanical injury, may be reviewed briefly as follows:

### *1. Galvanized pipe*

Galvanized pipe is probably the most popular service pipe material. It is cheapest in first cost of any pipe having a substantial coating supplied by the manufacturer. It is the easiest pipe installed because of the simple threaded joint and standard fittings. Unfortunately the zinc coating is not a permanently effective protection with many water supplies, while with some supplies corrosion is so rapid as to forbid use of this material. Discolored or rusty water appears in time at the faucet or in the water after heating, tubercles of iron rust form on the interior and may greatly reduce or stop the flow. Deterioration at the joint is apt to proceed rapidly, resulting in leakage.

Extensive study and research as to causes and abatement of iron pipe corrosion as it relates to water supply have been made. Notable among the investigations, concerned chiefly with the action of cold water in domestic service, are those of the Massachusetts Board of Health, 1900–1910 (4), (5), and the New York Board of Water Supply, 1911–1912 (6).

*Corrosion factors.* The investigations of Whipple (7), (8), of Weston (9) and of Walker (11) have added much to a practical knowledge of the subject, not to mention numerous others making

valuable contributions to some phase of corrosion. The observed and generally accepted facts as to behavior are: (*a*) Corrosion and deterioration of iron or steel service pipe is most prevalent with soft water supplies. (*b*) The principal factor determining the rate of corrosion and amount of iron dissolved is the free carbonic acid in the water, corrosion being most pronounced with high $CO_2$ content. (*c*) The dissolved oxygen in water accelerates corrosion and is responsible for the appearance of rust or tuberculation. (*d*) Corrosion decreases with increase in hardness of the water supply. (*e*) Galvanized steel pipes corrode more rapidly than galvanized wrought iron. (*f*) Protection of iron or steel galvanized pipe is at expense of the zinc coating which dissolves in the water. (*g*) Workmanship in manufacture and galvanizing is a decided factor in resistance to corrosion. (*h*) Filtration accelerates corrosion by removal of organic matter, and, where coagulants are used, the additional carbonic acid created may be a factor in some cases.

*Effect of metals dissolved from iron pipe.* The presence of dissolved iron or iron rust even in considerable amounts has no known hygienic significance. Iron in the amounts of 1 to 2 p.p.m. may impart an astringent taste characteristic of this metal, but waters containing much larger amounts are used without detrimental effect. The principal effect is the reddish stain or rust produced in the water, on plumbing fixtures and on clothes during laundry operations.

Zinc dissolved from galvanized pipe usually passes unnoticed and little consideration has been given to its relation to health. Howard (12) has recently summed up the situation as to physical effects and hygienic relations. Opalescence in the water first drawn from faucets in the morning and appearance of a "greasy film" are the visible evidences of appreciable quantities of dissolved zinc, though these evidences are apt to be confused with iron.

Regarding the amount of zinc present in water supplies, Howard states (12) that the New Hampshire tap water commonly contains 5 p.p.m. while 10 to 15 p.p.m. is "rather frequent."

In investigations for the Massachusetts State Board of Health by Clark (3), Clark and Gage (5) amounts of zinc were found ranging from 0 to 3.1 p.p.m. from typical galvanized services less than 100 feet in length in ordinary use. The same services, after letting the water stand over night, gave 2 to 12 times the amount of zinc in ordinary use. Unusually long services gave higher figures than those quoted.

Opinion and evidence as to harmful effects of drinking water contaminated with zinc are conflicting. Evidently the subject needs closer study both on the part of the physician and the water analyst.

*Remedies for corrosion of iron pipe.* With water supplies containing considerable amounts of carbonic acid, particularly ground waters, aeration has been found effective in reducing corrosion.

Hardening of the supply by addition of, or contact with, limestone has found a limited use.

Treatment of the water with lime has been found effective in numerous cases. Its use was discussed very thoroughly by Whipple (7) and the practical application of lime on a large scale is well-known through the Baltimore experience, as described by Baylis (14), (15). Lime has the disadvantage of increasing the alkalinity and total hardness by 1.14 p.p.m. for each part $CO_2$ neutralized.

Soda-ash treatment of the water is also a practical remedy against corrosion. It is more expensive than lime treatment, but has the advantage of not increasing the hardness; on the other hand, it reduces the permanent or non-carbonate hardness.

Silicate of soda has been used quite successfully in England as a remedy against corrosion for iron service pipe and red water troubles according to Thresh (16). Treatment with sodium silicate has been found an effective remedy for corrosion of hot water systems in this country according to Texter (20), but so far as known no application to a public water supply has been made.

### *2. Lead or lead lined pipe*

Next to galvanized pipe, lead is most favored for service pipe in this country. In England, according to Mitchell (19), a much larger proportion of services are of lead. It has the longest life and is free from the "red water" troubles common to galvanized iron and steel pipe. The installation cost of the lead service is more than for galvanized.

The greatest drawback to installation of lead service is the fact that lead is distinctly soluble with certain kinds of water and being an active and cumulative poison may constitute a grave menace to the health of those drinking water delivered through lead pipe. This property of lead pipe has been known for more than twenty centuries, and the instances of illness or death from drinking water from lead pipe are quite numerous, as evidenced by citations in the

excellent review of the subject by Weston (10). The instances of lead poisoning from American public water supplies available at the present time to this committee comprise only the New England towns listed in table 3. The list is obviously incomplete and based only on published information. There are a great number of water supplies in this country having characteristics similar to the New England waters where plumbism might be expected, and undoubtedly has occurred. Obscure symptoms, lack of thorough investigations and a fear of arousing public apprehension or of inviting litigation are the principal causes for silence or complacency as to possible plumbism, on the part of cities having a large proportion of lead services.

TABLE 3

*Localities in America where lead poisoning has been reported*

| CITY | YEAR | AUTHORITY | REFERENCE |
|---|---|---|---|
| Fairhaven, Mass | 1898 | Clark | (3) (4) |
| Kingston, Mass | 1898 | Clark | (3) (4) |
| Lowell, Mass | 1898 | Clark | (3) (4) |
| Lowell, Mass | 1899 | Barbour | (23) |
| Milford, Mass | 1898 | Clark | (3) (4) |
| Rhode Island | 1916 | Gage | (27) |
| Milford-Hopedale, Mass | 1914 | Weston | (10) |
| Gilbertville, Mass | | Whipple | (7) |
| Norwood, Mass | | Whipple | (7) |
| New Bedford, Mass | | Whipple | (7) |
| New Hampshire | | Howard | (13) |
| Atlantic City, N. J | | Hawley | (30) |

Within the past thirty years several thorough investigations as to the solvent and corrosive action of water on lead service pipe have been carried out, resulting in the establishment of certain needed facts, which deserve to be generally recognized.

The occurrence of serious lead poisoning or "plumbism" in certain towns of Central and Northern England having water supplies derived from moorland catchment areas caused the Local Government Board to initiate in 1890 an inquiry as to cause and extent. This investigation carried out by Dr. Houston occupied the better part of five years, the results of which were published in 1902 (21) and 1903 (22).

In 1896 the State Board of Health of Massachusetts prompted by a large number of cases of lead poisoning started an investigation

"to learn the nature and degree of the action of the water of the various public water supplies of the state upon lead, in such towns as use lead or lead-lined service pipes, and to ascertain facts in regard to the occurrence of lead poisoning in those towns." These investigations, covering about four years' work, were published in 1899 (3) and 1901 (4).

These two investigations may be said to have laid the groundwork for an understanding of the problems associated with the corrosion of lead service pipe, but the subsequent contributions by numerous other investigators, both in this country and abroad, must be recognized. In particular, the recent summary of the subject by Weston (10) should be mentioned.

*Action of water on lead.* Distilled water, completely free from dissolved gases, has no action on lead. In distilled water containing only dissolved oxygen, lead is dissolved with formation of the colloidal hydrate, giving an alkaline reaction to the liquid, which remains clear. The oxygen is used up unless in excess, in which case a deposit of definite crystalline character forms at the sautration point, stated by Thresh (17) to be about 20 mgm. per 100 cc. If carbon dioxide is present in addition to oxygen, a white turbidity appears due to formation of the oxycarbonate, and precipitation occurs on standing. Excess of carbon dioxide dissolves the lead as a bicarbonate, the liquid being clear. In presence of acids, lead undergoes true solution, in which form it is not removable by fine materials such as paper, Gooch, and Berkfeld filters.

These fundamental facts reported from carefully controlled laboratory experiments serve to explain the behavior of lead service pipe in actual water works practice. The two elements most concerned in lead corrosion, namely oxygen and carbonic acid, are present in most public water supplies, as distributed. In addition some surface water contains organic acid due to decomposition of vegetable matter.

In considering lead corrosion, it is important to distinguish clearly between what happens in (*a*) neutral or alkaline water in the presence of oxygen and (*b*) that occurring in acid water or in slightly alkaline water containing high carbonic acid, with or without oxygen. In the first condition, the metal becomes scaled and the water is made turbid. "Erosion" is the term generally used to describe this action, though it has been referred to, not inaptly, as "lead rusting;" while "solvency," or "plumbo-solvency," describes the second condition, where lead enters into true solution.

*Conditions for lead erosion.* Ordinary distilled water, rain water and melted snow erode rapidly, but do not dissolve lead appreciably. Natural water of low alkalinity and low $CO_2$ act similarly. Erosion decreases with an increase in alkalinity, the controlling amounts, according to Weston (10), for water containing less than 30 p.p.m. $CO_2$ being:

Alkalinity less than 15 p.p.m.—erosion, precipitate forms, metal appears bright, but mottled
Alkalinity 15 to 25 p.p.m.—rarely erode, crust of basic carbonate forms
Alkalinity over 25 p.p.m.—no erosion, protective coat forms

*Condition for lead solvency.* The controlling factor in lead-solvency is "acidity," from free carbonic acid, humic or peaty acids, or mineral acid. Those natural waters dissolving lead to an appreciable extent are (*a*) soft ground waters, high in carbonic acid, or (*b*) soft colored water derived from swampy catchment areas. The Massachusetts cases of lead-poisoning referred to above belong to the former class, while the English cases of plumbism were related to the latter class. Although no instances of plumbism from water containing mineral acid are known to this Committee, the possibility should be recognized. Many of our important public water supplies are taken from streams, actually acid or on the border line due to acid mine drainage or acid industrial wastes. The effect on lead services of chlorination of the supply has been stated in at least one instance, though the matter needs confirmation.

*When is a water supply safe from lead.* In connection with the early Massachusetts investigation, Clark and Forbes state (4) "a potable water in Massachusetts to have any dangerous lead dissolving action must contain considerable free carbonic acid." In the case of Lowell, Fairhaven, Kingston and Milford where plumbism occurred, the $CO_2$ ranged from 16 to 29 p.p.m. and the hardness from 10 to 28 p.p.m. At Lowell the Cook well water, condemned on account of its lead solvency, had an alkalinity of about 33 p.p.m., hardness of 55 and $CO_2$ content of 45 p.p.m., according to a later investigation by Barbour (23). Thresh states (19) that 40 p.p.m. alkalinity is required entirely to prevent action on lead. It is obvious that the solvency depends not on $CO_2$ content alone but on "true" acidity or "hydrogen-ion concentration," a term made very familiar to water works men within the last two or three years.

In the case of the peaty Moorland waters of England, Houston (21) (22) established a correlation between plumbo-solvency and the acidity to lacmoid. Lacmoid gives color changes from pH 4.4 red to 6.2 blue, according to W. Mansfield Clark (25). The English test is made very simply by adding a drop of lacmoid indicator to 10 cc. of water in a test tube, in the cold. A red color indicates acidity, and water giving this reaction was found by Houston to be plumbo-solvent. The action on lead was proportionate to the acidity. The amount of acidity is determined by titrating 100 cc. of water with sodium carbonate and phenolphthalein, in the cold. This conforms to our A. P. H. A. test for "total acidity" (26), and in the absence of organic or mineral acids represents "free carbon dioxide."

Thresh in a study of 42 Moorland waters (16) found pH ranging from 4.0 to 7.5 with an average of pH 6.3. These waters contained $CO_2$ (volatile acid) ranging from 1.0 to 5.5 p.p.m., non-volatile acidity from 0 to 15 p.p.m., alkalinity from 0 to 7.5 and hardness from 7.3 to 90.0 p.p.m. Although all the waters dissolved lead in laboratory tests, correlation of the figures stated with actual behavior in services was not shown.

Another test for action of water on lead is the "foil test" devised by Houston and modified by Liverseege and Knapp (see Weston, 10). A bright polished strip of sheet lead $\frac{1}{2}$ by 1 inch is submerged in a glass cylinder with water tested, from one to fourteen days. Erosion is apparent from the appearance and solvency is determined on a decanted portion, by suitable analytical methods.

Still another test of water for its action on lead is the "shot test," also due to Houston (21) and modified by Thresh (19). It consists in passing the water at a specified slow rate through a glass tube filled with clean pure lead shot, and determining the lead in the effluent.

On samples brought into the laboratory, corrosion tests sometimes fail to indicate the true condition as to lead corrosion in the distribution system. The London tap water cited by Thresh (19) and the Boston tap water cited by Weston (10) are examples of water supplies not giving rise to plumbism, yet showing considerable amounts of lead dissolved in laboratory tests. The differences are due to the protective coating found in the service pipe. Such protection may be due to films of organic matter, basic lead carbonate, or of lime or silica introduced artificially. For these reasons,

lead determinations on samples collected from service pipes in actual use are necessary for a complete study of the problem.

In sampling service pipe it should be borne in mind that the water standing in lead pipes dissolves more lead than when the faucets are used frequently. The Massachusetts investigations, already quoted, showed an average lead content of 0.37 p.p.m. in 16 ground-water supplies as sampled from the faucet in ordinary use, while the same faucet after standing over-night yielded 0.70 p.p.m. Similarly 6 surface supplies gave 0.02 and 0.44 p.p.m. respectively.

*Physiological effects of lead in drinking water.* The list of physiological symptoms attributed to lead-poisoning is formidable, these varying from mild unwellness, general debility, constipation, rheumatism, anemia, colic, contracted granular kidney, transient blindness, inflammation or atrophy of optic nerve, degeneration of blood vessels of the eye, to death. The susceptibility of individuals varies materially.

*Permissible amounts of lead in drinking water.* On this matter, opinion varies widely. Some authorities regard any amount of lead detectable by usual method of analysis as potentially dangerous, when the water is habitually drunk. An amount as high as 1.5 p.p.m. has been used without illness resulting, yet many cases of lead-poisoning have resulted from smaller amounts. Gage records (27) poisoning in Rhode Island from 0.2 p.p.m. Howard (13) in discussing the experience of the New Hampshire Board of Health, engaged for some twenty years in studying the relation of lead to water supplies, states that the formerly prevalent idea that 0.5 p.p.m. was a safe limit has been modified in the light of known cases of poisoning by half that amount. Weston (10) regards 0.1 p.p.m. as a practical safe limit though not necessarily a limiting maximum.

*Protective measures.* Treatment of waters to prevent corrosive action on lead pipe is neither difficult nor expensive. Such treatment has to do with elimination of acidity, building up a protecting alkalinity or formation of a protective coating without disturbing the chemical constituents of the water.

Aeration, in the case of ground waters containing high carbonic acid, is frequently a simple and effective means of reducing this constituent. With soft waters, however, aeration may be actually detrimental by reason of the dissolved oxygen added which increases the tendency towards erosion. Removal of carbonic acid by aeration is never complete. The most efficient aeration with

spray nozzles was found in the Memphis experiments by Donaldson (28) to leave a residual of about 3 p.p.m. while other types of aerators gave somewhat higher residual, on a water containing about 28 p.p.m. $CO_2$.

Application of lime to the water will completely neutralize all acidity. With ground waters high in carbonic acid it is better to first aerate in order to avoid increasing hardness of the water to an appreciable extent. American practice shows a preference for hydrated lime, fed with dry feed machines, rather than ordinary lump or quick lime.

Application of soda-ash serves the same purpose as lime in neutralizing acidity. It is more expensive, but does not harden water. Dry feed machines or solution tanks are equally serviceable for soda-ash.

Filtration through beds of limestone used to considerable extent in England has not found favor here, direct chemical treatment being preferred.

The application of sodium silicate has been tried in England with good results, but so far as known has not been used here in the treatment of public water supplies. It is stated to have a greater protective value than lime. There are numerous grades or varieties of silicate. That recommended for water purification has the composition $Na_2O$, 9 per cent, $SiO_2$, 29 per cent, water, 62 per cent (ratio 1:2.40). It is a slightly viscous fluid, best applied with a calibrated orifice valve arrangement.

### *3. Other service pipe materials*

As shown by table 1, tin-lined pipe is used to some extent for services. It was in fact recommended in the 1898 Massachusetts Report. Weston has shown (9) that tin-lined lead pipe is not a protection against lead corrosion, lead being dissolved in spite of the tin lining which remains intact.

Table 1 indicates that cement-lined pipe has considerable vogue in New England, but not elsewhere. This pipe has no appreciable effect on water passing through it and its use eliminates iron rust troubles except as these are due to the iron in the supply or to house plumbing troubles. The danger of lead-poisoning is of course eliminated by cement-lined pipe. The technique of protecting joints and of producing a satisfactory cement lining in the average

water works shop has deterred more general adoption of this kind of service pipe, though such difficulties are held lightly by those accustomed to the use of such pipe.

The behavior of brass service pipe hardly deserves mention as its use is very limited, on account of the expense. In a number of cities where the water supply is corrosive, some consumers have all-brass house plumbing, but the use of brass pipe for services in the street is exceptional. Brass pipe is usually affected little by water, though measureable amounts of both zinc and copper have been found in water from brass pipe (4).

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## PROGRESS REPORT OF COMMITTEE NO. 12 ON TESTING OF WATER WORKS MATERIALS AND SUPPLIES[1]

The committee has had its present organization only since the last annual meeting. On June 19, following general instructions from the President, a tentative outline of work of the committee was written by its chairman and sent to the President for approval. This outline, containing assignment of sub-committees, was published in the Journal. The committee members are spread from Boston to Kansas City and have not yet met. Some progress has been made, however, by individual work and correspondence and the results are presented herewith for the information of the Association and as a basis for discussion. The committee itself will meet at the coming annual meeting for discussion of this tentative report and to outline work for another year.

It has been assumed that Committee 12 is responsible for "testing" and hence for "specifications" under which are to be tested all materials not specifically covered by other committees, to wit; the following:

Committee on Standard Specifications for Water-meters
Committee on Standard Brass Fittings
Committee 9 on Standard Specifications for C. I. Pipe and Specials
Committee 10 on Standardization of Services
Committee 17 on Steel Pipe Lines

It may be fitting also for the committee to assemble accepted general rules for testing and inspection that will be applicable to all materials.

The words "materials and supplies" are not interpreted to include fabricated articles of a considerable degree of complication, such as pumps, stand-pipes, wood stave pipes, flexible-jointed pipes, hydrants, etc. These, though not covered by special committees, are manifestly too important to be lumped into the work of this committee and will only be considered from the viewpoint of covering

[1]This report has been prepared under the direction of Council, by Committee No. 12, Thomas H. Wiggin, Chairman.

the basic materials, such as rolled, cast and forged steel, cast iron, bronze, rubber, etc., which enter into their construction.

Obviously with all the standardization work that has been done by the American Society for Testing Materials, the American Engineering Standards Committee, the Bureau of Standards and other bodies jointly and severally, it is unnecessary for this committee to inaugurate new work on many important materials such as steel, cement, etc. Further on in the report the endeavor has been made to list such generally accepted standard specifications as exist and to give clear references which will enable members who are not familiar with these existing specifications to avail themselves of them.

By way of introduction to these references a brief explanation may not be amiss as to the rather complicated agencies that now exist in the United States for the compilation of standard specifications. Previous to the war the American Society for Testing Materials was the chief agency for concerted action of the engineering profession in making standard specifications. In general each separate society worked up and adopted its own specifications for materials and supplies with which it was primarily interested.

In 1917 concerted action was taken by the American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers and American Society for Testing Materials in establishing the American Engineering Standards Committee as a clearing house for specifications. There are now 205 national organizations participating in the A. E. S. C. work. The committee has offices in the Engineering Societies Building, 29 West 39th Street, New York City, with a paid secretarial personnel.

The American Engineering Standards Committee is a coördinating body. It neither proposes nor formulates specifications, but, when the demand for a standard specification is demonstrated, it aims to secure the widest practicable participation in the formulation of the specification and in its subsequent adoption. The specifications are formulated by so-called "Sectional Committees" having the special support of so-called "sponsor" organizations, which sponsors publish the specifications. Specifications which have been approved by the A. E. S. C. as American Standards or as Tentative American Standards are on sale separately by the A. E. S. C. as well as by the sponsors.

Some of the materials and supplies in which waterworks men are interested have already been acted upon or are in process of consideration by the A. E. S. C. Specifications for Portland cement and for pipe threads are two examples of specifications that have been so acted upon. Cast iron pipe and lime are examples of those under consideration. Action by the A. E. S. C. tends to delay a specification but to make it more broadly applicable. The various individual societies like our own must continue to work out their own salvation and must also keep in touch with the A. E. S. C. to make the products of their own work more generally useful and to be sure that their own special needs are properly represented in the Sectional Committees of the A. E. S. C.

Nearly all the specifications referred to below are American Society for Testing Materials Standards or tentative standards.[2] In some cases they are also A. E. S. C. Standards and are marked A. S. (American Standard) or T. A. S. (Tentative American Standard).

A. S. T. M. standards and tentative standards are all copyrighted in the name of the A. S. T. M. Permission to reprint any of these standards and tentative standards can be obtained only from the Executive Committee on application to the Secretary-Treasurer of the A. S. T. M., but it is usually sufficient to specify by name and serial designation of the A. S. T. M. Standard as in the following example: Plates for stand pipe shall fulfill the requirements for "Flange Steel" as given in the Standard Specifications for Boiler and Fire Box Steel for Locomotives, Serial designation A 30–21, of the

[2] A.S.T.M. Standard Specifications are published every third year, the last being 1921. Standards adopted in intervening years are published annually in a separate pamphlet. Tentative specifications are published annually in a volume containing all tentative specifications effective at the time. Tentative specifications are subject to revision at any time until adopted as standard; the latest edition should therefore be obtained. Pamphlets of separate standard or tentative specifications are sold at 25 cents per copy in lots of 1 to 50, less in quantities. Address American Soc. for Testing Materials, 1315 Spruce Street, Philadelphia, Pa., giving both serial designation and title of the specification. Thus, C 9-21 is Standard Specification for Portland Cement, the 21 designating year in which adopted or in which last revised. The number of a tentative specification is always followed by the letter T, thus A27-23T is tentative specification for steel castings.

For complete list of all Standard and Tentative Standard Specifications and for further particulars, see Year Book of A.S.T.M. ($1.00 to non-members).

American Society for Testing Materials. These specifications generally provide for the inspection of materials at the place of manufacture unless otherwise specified.

## SPECIFICATIONS OF THE AMERICAN SOCIETY FOR TESTING MATERIALS

### Steel

*Standard and Tentative Standard Specifications for:*

A 9-21 Structural Steel for Buildings. Covers open hearth rivet steel and both Bessemer and open hearth structural steel.

A 15-14 Billet-Steel Concrete Reinforcement Bars. Covers (*a*) plain, deformed and cold-twisted billet-steel bars; (*b*) plain and deformed bars of three grades, namely; structural-steel, intermediate and hard; and (*c*) cold-twisted bars.

A 16-14 Rail-Steel Concrete Reinforcement Bars. Covers plain, deformed and hot-twisted rail-steel bars.

A 27-21 Steel Castings. (See A 27-23 T.)

A 27-23 T Steel Castings (Tentative; to replace, when adopted, A 27-21). These alternative specifications cover Class A castings for which physical requirements are not, and Class B castings for which physical requirements are specified, the latter of three grades, hard, medium and soft. A 27-23 T differs from A 27-21 in that it accepts for Class A castings a higher carbon content subject to heat treatment, and for Class B castings requires greater elongation and reduction of area, but requires no bend test unless specified in the order.

A 36-14 Recommended Practice for Annealing of Carbon-Steel Castings. (See A 36-22 T.)

A 36-22 T Tentative Recommended Practice for Heat Treatment of Carbon-Steel Castings. (To replace, when adopted, A 36-14.)

A 36-14 Corresponds to A 27-21 though not specified therein; A 36-22 T is specified in A 27-23 T.

A 30-21 Boiler and Firebox Steel for Locomotives. "Flange steel" of A 30-21 used for boiler shells (not fireboxes), riveted pipes, standpipes and important tanks.

A 31-21 Boiler Rivet Steel. For boiler, pipe, standpipe and tank rivets.

### Wrought Iron

*Standard Specifications for:*

A 72-21 Welded Wrought-Iron Pipe. (T.A.S.) Covers "standard" and "extra-strong" welded wrought iron pipe, $\frac{1}{8}$ inch to more than 12 inch diameter, but not "double extra-strong" pipe; includes pipe of "coiling or bending quality."

*Standard Definitions of:*

A 81-21 Terms Relating to Wrought-Iron Specifications.

### Cast Iron and Finished Iron Castings

*Standard Specifications for:*

A 44-04 Cast-Iron Pipe and Special Castings. Listed as a matter of information. Differs from American Water Works Association Standard chiefly in a few minor differences in dimensions, and in accepting a load on test bar for pipe 12 inches or less in diameter of 1900 pounds instead of 2000 pounds, and in requiring a deflection under 2000 pounds load of 0.32 inch instead of 0.30 inch in bars for pipe larger than 12 inches; also does not provide for alternative tensile test.

A 74-18 Cast-Iron Soil Pipe and Fittings.

A 47-19 Malleable Castings. Covers malleable castings for railroad, motor vehicle, agricultural implement and general machinery purposes, produced by either air-furnace, open-hearth, or electric-furnace process, and specifies same properties and tests for all.

A 48-18 Gray-Iron Castings. Covers "light," "medium" and "heavy" castings with different test requirements for each class.

*Standard Methods of:*

A 64-16 Sampling and Chemical Analysis of Pig and Cast Iron.

### Metallic Protective Coatings for Iron and Steel

*Tentative Methods of:*

A 90-23 T Determining Weight of Coating on Zinc-Coated Articles. Describes one shop weighing test, three laboratory and three field tests, one of the laboratory methods being a tentative standard.

### Non-Ferrous Metals

*Standard and Tentative Standard Specifications for:*

B 7-14 Manganese-Bronze Ingots for Sand Castings. This specification is for ingots, such as might be used in a water department foundry, not for manganese-bronze castings; the properties of the castings being largely dependent upon details of foundry practice, may be quite different.

B 10-18 The Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent. Covers the alloy commercially known as government bronze, admiralty gun-metal, gun-metal, or 88-10-2 mixture, when used in castings.

B 15-18 Brass Forging Rod. Covers rods of any specified cross-section capable of being readily forged hot and easily machined; chemical requirements but no tensile tests.

B 21-19 Naval Brass Rods for Structural Purposes. Covers rods of any uniform cross section, such as round, hexagonal, square, etc., requirements varying with diameter. Suitable for structural purposes as rods, bolts, etc., and is capable of being forged hot but is not free cutting.

B 31-21 Bronze Bearing Metal in Ingot Form. Covers 6 grades of copper-tin-lead alloys, made wholly or partly from scrap material.

B 32-21 Solder Metal. Covers two classes and a total of 11 grades of lead-tin alloys used for "soft solder."

B 42-23 Copper Pipe, Standard Sizes. Covers seamless copper tubes and pipe suitable for use in plumbing, boiler feed lines, etc.; bending temper to be specified if required.

B 43-23 Brass Pipe, Standard Sizes. Covers seamless brass pipe suitable for use in plumbing, boiler feed lines, etc.; bending stock to be specified if required.

B 30-22 Brass Ingot Metal, Graded and Ungraded, for Sand Castings. Covers "red" and "yellow" brass ingot, made wholly or partly from scrap; seven grades, also ungraded.

B 44-23 T Seamless Admiralty Condenser Tubes and Ferrule Stock (Tentative). Covers seamless tubes and ferrule stock made from admiralty alloy, 70 per cent copper, 1 per cent tin, and 29 per cent zinc.

*Standard Methods of Chemical Analysis of:*

B 18-21 Alloys of Lead, Tin, Antimony and Copper. (T.A S.)

B 27-19 Manganese Bronze. (T.A.S.)

B 28-19 Gun Metal. (T.A S.)

B 45-23 Brass Ingots and Sand Castings.

B 46-23 Bronze Bearing Metal.

### Cement, Lime and Clay Products

*Standard and Tentative Specifications for:*

C 9-21 Portland Cement (A.S.)

C 9-16 T Compressive Strength of Portland Cement Mortars. (To be added when approved, to C 9-21.)

C 10-09 Natural Cement.

C 33-23 T Concrete Aggregates. Covers fine and coarse aggregates including sand, stone screenings, crushed stone, gravel and slag. Acceptance based on description and sieve tests plus concrete strength tests: or alternatively for sand, on mortar strength tests.

*Standard and Tentative Methods of:*

C 29-21 Test for Unit Weight of Aggregate for Concrete (T.A.S.) To determine weight of a given volume of dry aggregate, fine, coarse or mixed, with air-filled voids, relative to the same volume of water.

C 30-22 Test for Voids in Fine Aggregate for Concrete. (T.A.S.) Requires determination of "apparent specific gravity" by methods of D 55.

C 31-21 Making and Storing Specimens of Concrete in the Field. Covers molding and storing of test specimens sampled from concrete being used in construction.

C 39-21 T Making Compression Tests of Concrete.

C 40-22 Test for Organic Impurities in Sands for Concrete. (T.A.S.) Covers the sodium hydroxide test, which test is intended as an indication whether the presence of organic compounds requires further tests of the sand before its use in concrete.

C 41-22 Test for Sieve-Analysis of Aggregates for Concrete.

C 42-21 T Securing Specimens of Hardened Concrete from the Structure (Tentative).

C 44-22 T Tentative Rules for Inspection of Concrete and Reinforced Concrete Work. Covers qualifications of the inspector, and his duties in detail.

C 7-15 Paving Brick. Covers rattler test and visual inspection only.

C 21-20 Building Brick. Covers absorption, compression and transverse tests.

C 32-23 Clay Sewer Brick. Covers four classes according to resistance to abrasion required; provides for optional chemical tests and requirements; specific size, visual inspection, absorption, compression and transverse tests.

C 4-21 Drain Tile. (T.A.S.) Covers three classes, Farm Drain Tile, Standard Drain Tile and Extra-Quality Drain Tile, 4 to 42 inches.

C 13-20 Clay Sewer Pipe. Covers clay products intended to be used for the conveyance of sewage, industrial wastes, and storm water. Sizes 4 to 42 inches.

C 14-20 Cement-Concrete Sewer Pipe. Covers cement-concrete products intended for the conveyance of sewage, industrial wastes and storm water. Sizes 4 to 42 inches.

C 15-17 T Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling (Tentative). Gives required safe crushing strengths per linear foot of pipe, for different kinds and depths of ditch filling material over pipe, and different widths of ditch, when pipe is laid in accordance with C 12-19.

*Standard Definitions of:*

C 8-15 Terms Relating to Sewer Pipe.

*Recommended Practice for:*

C 12-19 Laying Sewer Pipe.

## Coal, Coke and Lubricants

*Standard Methods of:*

D 21-16 Sampling Coal. (T.A.S.)

D 22-21 Laboratory Sampling and Analysis of Coal.

D 22-23 Test for Fusibility of Coal Ash (To be combined with D 22-21 when the 1924 Book of A.S.T.M. Standards is issued).

D 37-21 Laboratory Sampling and Analysis of Coke. (T.A.S.)

D 47-21 Testing Lubricants (Specific Gravity, Free Acid, Carbon Residue, Viscosity).

*Definitions of:*

D 121-21 T Terms Relating to Coke (Tentative).

D 142-22 T Terms Relating to Coal (Tentative).

## Timber

*Standard and Tentative Specifications for:*

D 10-15 Yellow-Pine Bridge and Trestle Timbers.

D 23-20 T Structural Douglas Fir (Tentative). Covers "dense Douglas fir" and two structural grades.

*Standard Specifications of:*

D 9-15 Terms Relating to Structural Timber.

### Rubber Products

*Standard and Tentative Specifications for:*

D 14-23 Cotton Rubber-Lined Fire Hose for Private Fire Department use. Covers hose from 1½ inch single and double jacket to 3½ inch double and triple jacket.

D 26-23 Cotton Rubber-Lined Fire Hose for Public Fire Department Use. Covers 2½, 3 and 3½ inches double-jacketted hose.

D 53-23 T Rubber Belting for Power Transmission (Tentative). Covers friction covered and rubber covered belting.

D 151-23 Rubber Pump Valves. Covers valves for pumps equipped with grid-type seats and which are used for pumping fluids having very slight, if any, effect on rubber; five grades for various temperatures and pressures.

D 177-23 T Wrapped Cold Water Hose (Tentative). Covers cold water hose for other than public fire department use; sizes, ½-inch to 4 inches.

*Standard Methods of:*

D 15-15 Testing Cotton Rubber-Lined Hose.

### Road Materials—Aggregates

*Standard Method of Test for:*

D 30-18 Apparent Specific Gravity of Coarse Aggregates.

D 55-19 Apparent Specific Gravity of Sand, Stone and Slag Screenings and other Fine Non-Bituminous Highway Materials. Primarily for highway materials but used in determining voids in fine aggregates for concrete, C 30-22.

### Miscellaneous Subjects

E 1-18 Standard Method of Mechanical Testing of Metallic Materials. Covers methods for tension tests, compression tests, transverse tests and Brinell hardness tests; also calibration of testing machines.

E 4-23 T Tentative Methods of Verification of Testing Machines. (To supersede, when adopted, the corresponding parts of E 1-18).

E 6-23 T Tentative Definitions of Terms Relating to Methods of Testing.

## SPECIFICATIONS OF THE AMERICAN ENGINEERING STANDARDS COMMITTEE

A number of the A.S.T.M. Standards have been adopted by the American Engineering Standards Committee as American Standards or Tentative American Standards, of which the following have been previously listed (A.S.T.M. designations): A 72-21, B 18-21, B 27-19, B 28-19, C 9-21, C 29-21, C 30-22, C 40-22, C 4-21, D 21-16, D 37-21.

The following additional A.E.S.C. specification is presented (A.E.S.C. designation):

B 2-1919 Pipe Thread (American Standard). Sponsored by American Gas Association and American Society of Mechanical Engineers.

## MISCELLANEOUS SPECIFICATIONS SUGGESTED FOR DISCUSSION

The following specifications have been reported by various subcommittees of Committee 12. Some of them have been in satisfactory use for years and are doubtless known to members of the Association engaged in work requiring such materials. Some are modifications of standard specifications listed above. Alterations from common wording are indicated in a few cases. All are offered for information and for discussion.

### Lead

Lead shall be No. 1 quality—pure, soft lead practically free from all impurities. It shall show upon analysis not less than 99.5 per cent by weight of pure metallic lead.

### Jute

Jute shall be clean, sound, long fibre jute yarn, free from tar.

### *Portland Cement*

The A. S. T. M. Standard specification for portland cement, C9—21, which is also the American Standard of the A.E.S. Co., is presented with full realization that our knowledge of portland cement is imperfect and that a cement meeting the requirements of this specification may not produce sound concrete and durable structures, under certain occasional conditions, particularly with weather exposure. Pending a more comprehensive study than has yet been made, C 9—21 is the only generally recognized specification available. The Board of Water Supply of the City of New York uses C 9—21 except for the following requirements:

*a.* Sulphuric anhydride ($SO_3$) and magnesium oxide (MgO) shall not exceed 1.75 per cent and 4.00 per cent respectively, these being the values in force before specification C 9 was relaxed in 1917; and

*b. In recent specifications only,* the molecular ratio of the calcium oxide divided by the sum of the molecular ratios of the silicia, alumina and ferric oxide shall, in general, be greater than 2.40.

The sulphuric anhydride and magnesium oxide are held down mainly because there appears to be no sufficient reason for relaxing these requirements. The molecular ratio requirement is designed to insure sufficient lime to produce the several cementing ingredients

in what seem to be desirable proportions;[3] and while this requirement has not been in force long enough conclusively to prove its worth, the indications are that it is a useful provision, at least with current American cements. No case of disintegration of *underground* concrete placed either before or since the adoption of this requirement is known, except where exposed to sulphate ground waters.

### *Bronze*

The specification B 7—14, noted above, is for manganese-bronze ingots, not for castings. The following specifications are used by the Board of Water Supply of the City of New York for manganese or Tobin bronze castings and forgings.

| | MINIMUM REQUIREMENTS | | |
|---|---|---|---|
| | Castings | Forgings (a) | Forgings (b) |
| Ultimate strength, pound per square inch... | 65,000 | 70,000 | 80,000 |
| Yield point, pound per square inch..... | 32,000 | 35,000 | 40,000 |
| Elongation, per cent..... | 25.0 | 28.0 | 22.5 |

After being forged into a bar, rolled, forged or extruded bronze shall stand, first, hammering hot to a fine point; second, bending cold through an angle of 120 degrees to a radius equal to the thickness of the bar without showing signsof fracture.

All forged, extruded or hot-rolled bronze shall be subject to test with a scleroscope, and if a hardness is found materially exceeding that typical of hot-worked metal, the bronze shall be rejected or annealed promptly, as directed.

All bronze articles shall be made of new metal, shall be free from objectionable imperfections and shall conform accurately to required dimensions. The use of chaplets will not be permitted in centering or anchoring cores in cored pressure castings. When any material is being machined or inspected, if the metal shows signs of imperfect mixing it shall be rejected. All bronze castings, stems, rods, bolts, tubes and plates shall be free from season cracks, surface cracks or other defects; any casting, stem, rod, bolt, tube, or plate which develops any such defects within a year after delivery shall be promptly replaced at the Contractor's expense.

Bronze stems shall be forged from cast billets machined to remove imperfections. The reduction, by forging, of the cast billets shall be sufficient to carry the working of the metal to the denter of the completed stem or rod.

[3] "Judging the Quality of Portland Cement," by R. J. Colony, Trans. Am. Inst. Mining Eng., 1921.

If required, test-pieces shall be cut from the center of the stems to show the condition of the metal at that point. Bronze rods shall be forged, hot rolled or extruded from cast and machined billets. All bronze plates shall be hot rolled, except plates less than ¼ inch thick, which may be cold rolled and annealed. All bronze tubing shall be seamless-drawn, semi-annealed, made of approved commercial bronze. All bronze bolts shall be machined from rolled or extruded rods the full size of the heads. No cold rolling, cold passing or cold drawing will be allowed except for plates less than ¼ inch thick and for tubing. Cold straightening shall be done by approved bending.

Test-pieces for stems, rods, bolts or plates shall be provided as directed, the number required depending upon the importance of the work. Test-pieces for forgings shall be cut from the full-size section of the finished forgings. In large forgings, the test-piece shall be taken from a point located from the outer shell a distance equal to one-sixth of the diameter of the forged rod.

Patching or plugging of bronze castings will not be allowed, except for minor defects, and then only when and in such manner as may be approved. Welding or burning will not be allowed.

The prohibition of welding or burning for the patching of imperfect bronze castings is now absolute; no castings are known to have cracked that had not been burned, and there are few if any burned castings but have cracked, some cracks not developing for years. Bronze forgings are used chiefly for valve stems. All of the forgings which have been long in service were bought under substantially specification (*a*); the higher strength and lower elongation of specification (*b*) has been used only since 1922 with a view to getting a stiffer stem and one less likely to grind in the nut. The specifications for rolled or extruded manganese bronze are omitted as this material is rarely used. Bronze bolts, being subject to fatigue failure if overstressed in assembling, are not used in vital places. Yield point is specified, since, in the copper alloys at least, this rather than ultimate strength limits working stresses. Chemical properties are not specified.

### *Galvanizing*

The first steps toward the formulation of standard specifications for the zinc coating of materials of iron and steel were taken at a conference held in New York on January 29 under the auspices of the American Engineering Standards Committee. At this meeting your committee was represented, and the fact that a protective coating which gives good service under atmospheric exposure may be wholly inadequate with under-water exposure was brought out.

The tentative program contemplates specifications for the zinc coating, for different classes of exposure, of all classes of iron and steel materials commonly galvanized. It is the purpose of your committee to keep in touch with this work.

## CHEMICALS USED IN WATER PURIFICATION

### Quick Lime

Section 1. All lime furnished under this contract shall be the best quality of fresh burned fat lime, crushed and ground so that no lumps shall be greater than two inches in any dimension.

Sec. 2. The lime shall be delivered in tight box cars, loaded in bulk. Especial care shall be exercised to close all openings by which the lime might sift out, and to prevent the circulation of air and the admission of moisture.

Sec. 3. The lime shall be delivered at a uniform rate not to exceed....tons per week, as shall be directed.

Sec. 4. The percentage of water soluble calcium oxide in each car load lot of lime delivered will be determined from the analysis of a composite sample collected on its arrival at the water purification works. For any car load lot containing 88 per cent of water-soluble calcium oxide the City will pay to the Contractor the price per ton stated in the proposal. It is hereby agreed that the City shall pay a bonus of one and one-half per cent (1.5 %) of the contract price per ton for each one per cent (1%) by which the water-soluble calcium oxide in any carload lot delivered shall exceed eighty-eight per cent (88%) and shall deduct a penalty of one and one-half per cent (1.5%) of the contract price per ton for each one per cent (1%) by which the water-soluble calcium oxide in any carload lot shall be less than 88 per cent.

Sec. 5. If, in any carload lot, the material as delivered shall contain less than eighty-two per cent (82%) of water-soluble calcium oxide it will be rejected and shall be removed by the Contractor at his expense, and the cost of unloading the material from and reloading into the car shall be deducting from the amount payable to the Contractor under the terms of this contract.

Sec. 6. The carload lot as a unit will be used as the basis of accounting and determining the amount payable to the Contractor under this contract.

Note: A Sectional Committee of the A.E.S.C. is working on specifications for lime for all purposes. The A. W. W. Assn. is represented on this Committee.

### Soda Ash

Section 1. The soda ash shall be that known as 58 per cent light soda ash, and shall contain not less than 98 per cent sodium carbonate. The material shall be in a dry powdered form, shall contain no large lumps or large crystals, shall be free from chips and other foreign matter.

Sec. 2. The material shall be packed in bags 100, 200 or 300 pounds per bag, bags to become property of the Purchaser. Shipments of soda ash shall start .....19.. and shall continue at a uniform rate of not less than ....tons per week, or at such increased rate not to exceed....tons per week, as shall be directed.

### Sulphate of Alumina

Section 1. The material shall be that known as basic sulphate of alumina, containing no free acid. It shall be crushed into small lumps ranging in size from — to— inch, and shall be free from chips and other foreign matter. It shall contain not less than 17 per cent of available water soluble alumina, $Al_2O_3$, and of this alumina content there shall be at least 0.5 per cent[4] of its weight in excess of amount theoretically required to combine with the sulphuric acid present. The material shall contain not more than 0.5 per cent of matter insoluble in cold distilled water.

Sec. 2. Sulphate of alumina shall be shipped, unsacked, in tight box cars; the cars shall be thoroughly cleaned before leading, the door openings shall be boarded up to a suitable height, and all openings by which the material might waste shall be carefully closed.

Sec. 3. Each carload lot of material will be analyzed, on delivery, and the acceptance of the lot will be determined by the amount of alumina and of insoluble matter shown by this analysis to be present.

Sec. 4. If the material in any carload lot as delivered fails to meet the specifications of Section 1, it will be rejected and shall be removed by the Contractor at his own expense, and the cost of unloading and reloading the material shall be deducted from the amounts payable to the Contractor under this contract.

Committee No. 4 of the Association is investigating this subject and will probably make suggestions as to the best composition of coagulants.

### Bauxite

Section 1. The bauxite shall be crushed and dried to contain not over four per cent (4%) moisture. Unless otherwise permitted the analysis shall satisfy the following specifications:

$Al_2O_3$ not less than 54 per cent

$FE_2O_3$ not more than 5 per cent

Sec. 2. Bauxite shall be shipped unsacked in tight box cars; the cars shall be thoroughly cleaned before loading, the door openings shall be boarded up to a suitable height and all openings by which the material might waste shall be carefully closed.

Sec. 3. Deliveries shall begin..... and continue at the rate of .... cars per month.

### Sulphuric Acid

Section 1. The Sulphuric Acid shall be approximately 60 degrees Baume at 60 degrees Fahrenheit. It is understood and agreed that the seller is privileged to deliver acid of greater or lesser strength than sixty (60) degrees Baume. For any excess or deficiency in such acid above or below sixty (60) degrees Baume, a proportionate increase or reduction shall be made in the price per ton, according to the percentage of sixty (60) degrees acid contained in such

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[4]Tentative change from 3 per cent usually specified. The change is in line with recent studies of colloidal action.

acid of higher or lower degree, as set forth in the table of Manufacturing Chemists Association of the United States.

SEC. 2. Shipments shall be made in Sellers' tank cars, as directed.

### CHLORIDE OF LIME OR BLEACH

SECTION 1. Chloride of Lime shall contain not less than thirty-five per cent (35%) of available chlorine.

SEC. 2. It shall be packed in sheet iron drums 700 to 800 pounds per drum.

### LIQUID CHLORINE

SECTION 1. The liquid chlorine shall be practically a chemically pure anhydrous chlorine gas.

SEC. 2. Liquid chlorine shall be shipped in steel cylinders provided with suitable valve for controlling flow of chlorine. Each cylinder shall contain approximately from 100 to 150 pounds of chlorine.

## ORGANIZATION OF COMMITTEE 12

The following list shows the sub-committees of Committee 12. One change has occurred during the year, namely, the resignation of Mr. John H. Gregory and the appointment of Mr. L. P. Wood, Assistant Engineer, Board of Water Supply, New York City, to fill the vacancy.

| | |
|---|---|
| Compilation of Existing Standard Specifications | L. P. Wood<br>T. H. Wiggin |
| Alum<br>Sulphuric acid<br>Bauxite<br>Soda ash<br>Caustic soda<br>Ferrous sulphate<br>Copper sulphate<br>Bleach<br>Liquid chlorine | C. B. Hoover, Chairman<br>Richard Merriman<br>A. V. Graf |
| Lime | T. Merriman<br>C. B. Hoover<br>T. H. Wiggin |
| Brass<br>Bronzes<br>Copper<br>Monel metal<br>Nickel steel | T. Merriman<br>T. H. Wiggin |
| Cast iron (except for water pipes) | W. R. Conard<br>F. A. McInnes |
| Lead and Jute | F. A. McInnes |
| Lumber | Richard Merriman |
| Bolts and Gaskets | L. P. Wood<br>F. A. McInnes |

# PROGRESS REPORT OF COMMITTEE NO. 18 ON FILTER SAND ANALYSIS[1]

The Committee on Filter Sand Analysis does not feel that it is practicable or desirable to present a report with recommendations during the present year. Therefore, the committee merely submits a progress report intended to draw out discussion.

To stimulate discussion, certain questions that have been raised by members of the committee and others are set forth.

The specific duty assigned to the committee is that of inquiring into methods for testing and recording filter sand. These items can not, however, be intelligently discussed without considering rather fully experiences with the use of filter sand. In this particular it is hoped by the committee that the discussion will be especially extended.

To clear the way for further discussion a short historical sketch of the examination of filter sand follows:

## HISTORICAL

At the Lawrence Experiment Station of the Massachusetts State Board of Health, established in 1889 the need was soon recognized for some means of conveniently and accurately determining the size and uniformity of sands and gravels. A method was worked out by Mr. Allen Hazen, then chemist at the experiment station, based on the average actual dimensions of the particles and the use of plottings for showing the characteristics of the materials with reference to filtration.

For large particles, hand picking, weighing and the determination of specific gravity were used to ascertain the range of size.

For small gravel and sand, separations were made with carefully selected sieves. The sieves in turn were calibrated either by direct measurement of the diameters of the particles under a microscope or

[1]Prepared under the direction of Council. The personnel of Committee No. 18 follows: Paul Hansen, chairman, Chicago, Ill.; M. Z. Bair, Little Rock, Ark., G. C. Catlett, Raleigh, N. C., E. S. Chase, Boston, Mass., H. F. Ferguson, Springfield, Ill., G. C. Habermeyer, Urbana, Ill., H. N. Jenks, Berkeley, Calif., P. B. Streander, Darby, Pa., and J. E. Williamson, New York, N. Y.

by counting the last particles to pass a sieve, weighing them and determining their average diameter by a specific gravity method.

For very fine particles, a somewhat empirical method of elutriation with water was used.

For convenience, the results of separations by sieves, hand picking and elutriation were plotted with percentages by weight as ordinates and grain sizes as abscissa usually on logarithmic scales as such scales give a straighter curve.

As a result of observation and experiment at the experiment station, Mr. Hazen concluded that the "effective size" for filtration was that size of grain of which 10 per cent of the material was finer than itself and that the uniformity or non-uniformity could best be measured by a "uniformity coefficient," described as the ratio of the weight of that portion of which 60 per cent was finer than, to the weight of that portion of which 10 per cent is finer than.

Hazen's method of examining sands was so well worked out and the logic of it was so clear that it was generally adopted by engineers and has been almost universally used in the United States ever since.

### COMMENT ON HAZEN'S METHOD

Perhaps it has been too blindly used, especially in the acceptance of the definitions of "effective size" and "uniformity coefficients," but this is not Mr. Hazen's fault because he was very careful in defining these terms to refer to his definitions "as a provisional basis which best agrees with the known facts."

The question may be raised (and this is one upon which the committee would like further discussion): Should the effective size be based upon that size of which there is 10 per cent finer than or should some other percentage be chosen?

In his experiments on friction losses in the passage of water through sands, Hazen assumes that sand as used in filtration is uniformly mixed and that filtration takes place throughout the body of the sand bed. This is also reflected in the following statement from the 1892 report.

> The results obtained at Lawrence indicate that the finer 10 per cent have as much influence upon the action of a material in filtration as the coarse 90 per cent. This is explained by the fact that in a mixed material, containing particles of various sizes, the water is forced to go around the larger particles and through the finer portions which occupy the intervening spaces, and so it is this finest portion which mainly determines the frictional resistance, the capillary attraction, and in fact the action of the sand in almost every way.

In only a few cases, as far as the committee is aware, has filter sand been specified on any other basis than the effective size and uniformity coefficient as defined by Hazen. For the Albany slow sand filters, Hazen himself and for the Pittsburg slow sand filters, Morris Knowles specified a more or less complete gradation of sand. For Hazen's specifications, see JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION for 1915, page 509. Knowles' Pittsburg specifications read:

> Not more than 0.5 per cent by weight shall be less than 0.13 mm. not more than 7 per cent less than 0.26 mm. At least 7 per cent by weight shall be less than 0.34 mm., at least 70 per cent less than 0.83 mm. and at least 90 per cent less than 2.1 mm.

This in effect defines the effective size as that size of which 7 per cent is finer than itself.

In the case of rapid sand filters, the process of washing the filter tends to grade the sand bringing the finer particles to the surface where the major portion of the filtration takes place. Furthermore the washing process tends to increase the uniformity of the sand grains thus reducing the uniformity coefficient. This in turn tends to increase the percentage and size of voids. For rapid sand filters, there would seem to be an especially good reason for reducing the percentage of sand below the effective size.

Offsetting the above consideration is the fact that the lower the uniformity coefficient or the more nearly the sand grains are of the same size the more unimportant becomes the percentage below the effective size because a variation one way or the other makes no appreciable difference. The limiting case occurs with a sand having a uniformity coefficient of unity in which case for all practical purposes any grain represents the effective size.

## ABRAM'S FINENESS MODULUS

As having a possible application to the examination of filter sand, attention has been called to the work of Prof. Duff. A. Abrams on the examination of fine and coarse aggregates with reference to the effect of grading on the strength of concrete. Prof. Abrams uses W. S. Tyler Company's standard sieves made of wire mesh. These mesh sieves are woven especially for the purpose and correspond approximately to the standards of the United States Bureau of Standards. A nest of screens is chosen in which the clear opening

in each sieve is double the next smaller size and half the next larger; thus the areas of the openings increase approximately in the ratio of squares and the volume or weight (assuming uniform specific gravity) of particles passing increases in the ratio of cubes. These are essentially the same standard screens used in the "Tentative Method of Test for Sieve Analysis of Aggregates for Concrete" of the American Society of Testing Materials.

This gradation of sizes has a certain advantage in that the diameters when plotted on a logarithmic scale give even spaces and thus facilitate an examination or an analysis of curves. It must be borne in mind, however, that the actual diameter of the separated grains will not vary exactly in the geometrical progression of two. The accuracy may be sufficient for ordinary purposes if the sieves are very closely uniform.

Professor Abrams has devised the term "fineness modulus" which is defined as the sum of the percentages of the material coarser than that separated by each sieve divided by 100. Typical analyses and plottings are given in table 1 and the method of plotting is shown in figure 1.

The term fineness modulus gives much the same information concerning a sand as Hazen's uniformity coefficient, but it adds some information regarding the size of the particles inasmuch as the value of the coefficient increases more or less directly with the size of particles. A smooth standard gradation of material might be represented by a straight line on the diagram and the fineness modulus would have a value measured by the area under the line. A larger value than this would indicate a preponderance of large material and a smaller value would indicate a preponderance of smaller material.

Abrams' demonstration that any two mixtures of material used as concrete aggregates and having the same fineness moduli produce the same strength of concrete, other factors such as cement, water, etc. being equal. He also demonstrates that the same quantity of water is required to give maximum strength of concrete with aggregates having the same fineness modulus, other factors being equal. It would appear from this that two sand mixtures having the same fineness modulus would have the same voids or a disposition of particles that might give the same loss of head to the passage of water. This may be worthy of investigation with the apparatus used by Hazen to determine resistance to the passage of water.

From the diagram it would be possible to ascertain the screen separation or the calibrated size of which there is 10 per cent or any other per cent finer than, in order to obtain the effective size as defined by Hazen.

Perhaps the best information that could be obtained from Abrams' method as applied to filter sand analyses would be a statement of the

TABLE 1

*Method of calculating fineness modulus of aggregates*

The sieves used are commonly known as the Tyler standard sieves. Each sieve has a clear opening just double that of the preceding one.

The sieve analysis may be expressed in terms of volume or weight.

The fineness modulus of an aggregate is the sum of the percentages given by the sieve analysis, divided by 100.

| Sieve Size | SIZE OF SQUARE OPENING | | SIEVE ANALYSIS OF AGGREGATES—PER CENT OF SAMPLE COARSER THAN A GIVEN SIEVE | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Sand | | | Pebbles. | | | Concrete Aggregate (G)† |
| | Inches | Millimeters | Fine (A) | Medium (B) | Coarse (C) | Fine (D) | Medium (E) | Coarse (F) | |
| 100 mesh | 0.0058 | 0.147 | 82 | 91 | 97 | 100 | 100 | 100 | 98 |
| 48 mesh* | 0.0116 | 0.295 | 52 | 70 | 81 | 100 | 100 | 100 | 92 |
| 28 mesh* | 0.0232 | 0.59 | 20 | 46 | 63 | 100 | 100 | 100 | 86 |
| 14 mesh* | 0.046 | 1.17 | 0 | 24 | 44 | 100 | 100 | 100 | 81 |
| 8 mesh | 0.093 | 2.36 | 0 | 10 | 25 | 100 | 100 | 100 | 78 |
| 4 mesh | 0.185 | 4.70 | 0 | 0 | 0 | 86 | 85 | 100 | 71 |
| ⅜ inch | 0.37 | 9.4 | 0 | 0 | 0 | 51 | 66 | 86 | 49 |
| ¾ inch | 0.75 | 18.8 | 0 | 0 | 0 | 9 | 25 | 50 | 19 |
| 1½ inch | 1.5 | 38.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fineness modules..... | | | 1.54 | 2.41 | 3.10 | 6.46 | 6.86 | 7.36 | 5.74 |

*(Note added at fifth printing, October, 1922). The No. 48, 28, and 14-mesh sieves give the same separation as the No. 50, 30, and 16 now used in the "Tentative Method of Test for Sieve Analysis of Aggregates for Concrete" of the American Society for Testing Materials. The No. 50, 30, and 16 sieves are now used in all our tests.

†Concrete aggregate "G" is made up of 25 per cent of sand "B" mixed with 75 per cent of pebbles "E". Equivalent gradings would be secured by mixing 33 per cent sand "B" with 67 per cent coarse pebbles "F", 28 per cent "A" with 72 per cent "F," etc. The proportion coarser than a given sieve is made up by the addition of these percentages of the corresponding size of the constituent materials.

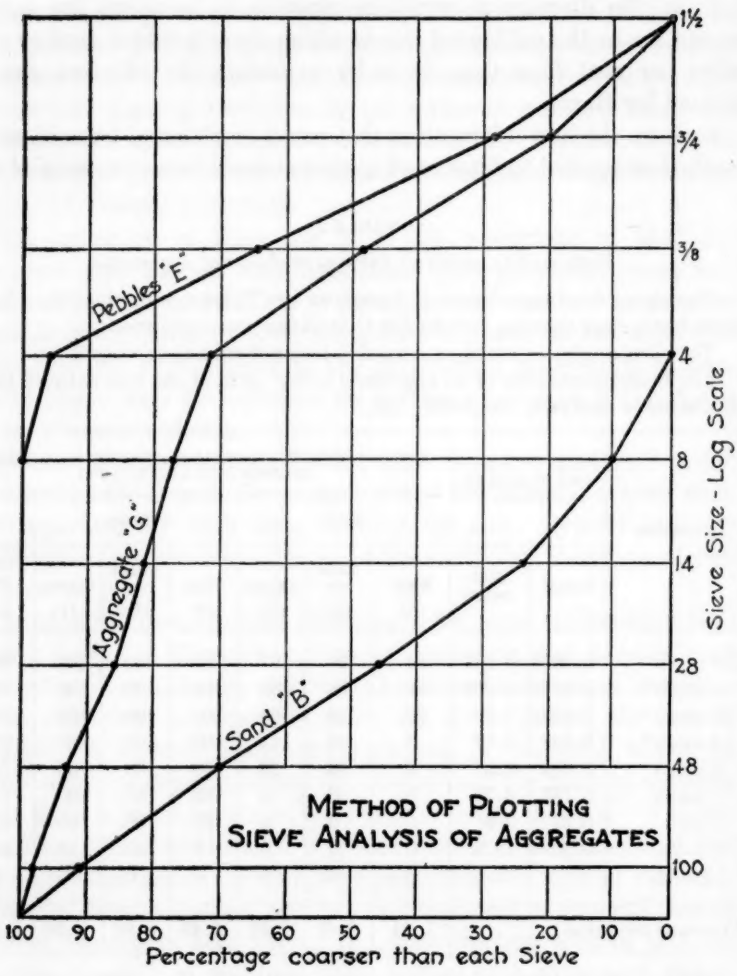


FIG. 1

maximum size and the fineness modulus. To describe the "maximum size," Abrams' formula may be used as follows:

If more than 20 per cent of the aggregate is coarser than any sieve the maximum size shall be taken as the next larger sieve in the standard set; if between 10 and 20 per cent is coarser than any sieve, the maximum size shall be the next larger "half-sieve;" if less than 10 per cent is coarser than certain sieves the smallest of these sieves shall be considered the maximum size.

If it can be definitely shown that the "fineness modulus" can furnish any additional information concerning the behavior of filter sands beyond that now given by Hazen's method, there may be an advantage in adopting it and dropping the term "uniformity coefficient," especially if the use of the fineness modulus gains wide currency in the examination of sands and gravels for purposes other than filtration.

### DIAMETER IN MILLIMETERS VERSUS SIEVE MESH

More or less criticism of the Hazen method has been aimed at the use of millimeters in giving the effective size of sand as being beyond the understanding of contractors or alarming to them because implying undue scientific exactness. This practice has gained such currency in the last thirty-five or more years that this apprehension would seem to be somewhat exaggerated.

Nevertheless, some simplicity would undoubtedly result if it were feasible to express the results of sand analysis in terms of separations by standard sieves rather than in terms of average diameters or diameters of equivalent spheres measured in fractions of millimeters. But this must be predicated upon the prior manufacture and general acceptance of standard sieves of a reliable degree of accuracy. It was precisely because of the absence of such sieves that Hazen worked out methods of measuring the size of sand grains and calibrating sieves so that the results of analyses might be expressed in terms of the sizes of sand grains rather than in terms of meshes to the inch or other sieve characteristics. The advisability of a change from the Hazen method, therefore, narrows down to a decision as to whether there is now available a generally accepted, readily available and officially adopted set of sieves.

### RELATIVE STANDARDIZATION OF SIEVES

In 1914, Mr. Philip Burgess presented a paper before the Association that was in substance a plea for the adoption of sieve separations to express the analyses of a sand. As considerable discussion developed both in favor and against the proposal a committee was formed to inquire more fully into the subject. The members of this committee were as follows: Philip Burgess (chairman), George W. Fuller and Edgar M. Hoopes, Jr.

This committee did not report until 1918 partly because its members were unable to agree upon any definite recommendations for a revised method of sand analysis and partly because the Committee awaited action on the part of the United States Bureau of Standards in devising specifications for standard sieves as well as concordant action on the part of manufacturers and users of analysis sieves.

Up to 1916 the Bureau of Standards had standardized only two sieves, namely, those having 200 meshes to the inch and those having 100 meshes to the inch. These were used primarily for cement testing.

On April 20, 1917 the Bureau of Standards arranged a conference at Washington including representatives of many engineering and technical societies interested in the adoption of standard sieves. The conference after considering a number of sieve scales adopted a sieve scale as standard and recommended its general use. The committee of the American Water Works Association recommended this standard for use in the mechanical analysis of filter sands but no formal action by the Association was taken. This sieve scale is described in the committee's report as follows:

> The screen scale is essentially metric. The sieve having an opening of 1 mm. is the basic one and the sieves above and below this in the series are related to it by using in general the square root of 2, or 1.4142, or the fourth root of 2, or 1.1892, as the ratio of the width of one opening to the next smaller opening. The first ratio, that is 1.4142, is used for openings between 1 and 8 mm., while the second ratio is used for openings below 1 mm. to give more sieves as required in that part of the scale.
>
> Because of the possible wide range of openings in sieves now manufactured with a given number of meshes of wire per unit length, due to the use of wires of different diameters, and because of the consequent confusion and uncertainty which arise in designating sieves by the number of meshes per unit length, the sieves of this series are designated by the width of the opening in millimeters, as for example a 1.41 mm. sieve, or a 0.36 mm. sieve. The committee recommends that this method of designating sieves be adopted instead of the customary method of designating the number of meshes per inch.
>
> To meet the need for sieves of this series at the present time the committee has included a temporary provision in the specifications for the acceptance of sieves of slightly different mesh and wire diameter than that called for in the screen scale, provided the resultant opening is the same as the nominal opening within a small range. This will make possible the use of a number of sieves now on the market in which the ratios of wire diameter to opening are only slightly different from those of the screen scale.

*Specifications for standard sieves*

Sieves shall be of brass constructed in diameters of 20 cm. (7.87 inches) or 15 cm. (5.91 inches). These are the outside diameters of the bottom of the sieves or the inside diameters of the top of the sieves.

Wire cloth for standard sieves shall be woven (not twilled, except that the cloth of 0.062 mm. sieves, may be twilled until further notice) from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame—the joint shall be smoothly filled with solder, or so made that the material will not catch.

The number of wires per centimeter of the cloth of any given sieve shall be that shown in the accompanying table 2 in the second column, headed "Mesh," and the number of wires in any whole centimeter shall not differ from this amount by more than the tolerance given in the fifth column, that headed "Mesh" under the heading "Tolerances." No opening between adjacent parallel wires shall be greater than the nominal width of opening for that sieve by more than the following amounts:

Five per cent of the nominal width of opening for the 8 mm. to 1 mm. sieve, inclusive.

Ten per cent of the nominal width of opening for the 0.71 mm. to the 0.36 mm. sieve, inclusive.

Twenty per cent of the nominal width of opening for the 0.25 mm. to the 0.125 mm. sieve, inclusive.

Thirty per cent of the nominal with of opening for the 0.088 mm. and the 0.62 mm. sieve, inclusive.

The diameters of the wires of the cloth of any given sieve shall be that shown in the third colum of table headed "Wire Diameter," and the average diameter of the wires in either direction shall not differ from the specified diameter by more than the tolerance given in the last column of table, that under "Tolerances" headed "Diameter."

Sieves shall be rejected for obvious imperfections in the sieve cloth or its mounting, as for example, punctured, loose or wavy cloth, imperfections in soldering, etc.

Until further notice, to permit the use of sieves now on the market which have slightly different mesh and wire diameters from that specified above, sieves will be satisfactory if the measurememts of mesh and wire diameters show the resulting average width of opening to be within 4 per cent of the nominal opening of a given sieve, and the ratio of wire diameter to opening of the sieve in question is within 0.03 of that given in the table, in the column headed "Ratio Wire Diameter to Opening" for the 8 mm. to the 2 mm. sieves, inclusive, and within 0.06 of the ratio given for sieves of smaller openings than 2 mm.

Since the submission of the Committee's Report in 1918, the Bureau of Standards has somewhat modified its standards so as to bring them more nearly in accord with manufactured products. These modifications do not relate to the diameters of openings or the

TABLE 2

*Standard screens for mechanical analyses of sand*

| | WIDTH OF OPENINGS | MESH | WIRE DIAMETER | RATIO WIRE DIAMETER TO OPENINGS | TOLERANCES | |
|---|---|---|---|---|---|---|
| | | | | | Mesh | Diameter |
| Metric | 8.00 | 1.00 | 2.00 | 0.25 | 0.01 | 0.008 |
| Customary | 0.315 | 2.54 | 0.079 | 0.25 | 0.03 | 0.003 |
| Manufactured | 8.05 | 2.5 | 0.083 | 0.26 | | |
| Metric | 5.66 | 1.4 | 1.48 | 0.26 | 0.01 | 0.08 |
| Customary | 0.223 | 3.56 | 0.056 | 0.26 | 0.03 | 0.003 |
| Manufactured | 5.66 | 3.5 | 0.063 | 0.28 | | |
| Metric | 4.00 | 2.0 | 1.00 | 0.25 | 0.02 | 0.05 |
| Customary | 0.157 | 5.1 | 0.039 | 0.25 | 0.05 | 0.002 |
| Manufactured | 4.04 | 5.0 | 0.041 | 0.26 | | |
| Metric | 2.83 | 2.75 | 0.81 | 0.29 | 0.02 | 0.05 |
| Customary | 0.111 | 7.0 | 0.032 | 0.29 | 0.05 | 0.002 |
| Manufactured | 2.82 | 7.0 | 0.032 | 0.29 | | |
| Metric | 2.00 | 3.9 | 0.56 | 0.28 | 0.04 | 0.05 |
| Customary | 0.079 | 9.9 | 0.022 | 0.28 | 0.1 | 0.002 |
| Manufactured | 2.03 | 10.0 | 0.020 | 0.25 | | |
| Metric | 1.41 | 5.0 | 0.59 | 0.42 | 0.08 | 0.025 |
| Customary | 0.555 | 12.7 | 0.0232 | 0.42 | 0.2 | 0.001 |
| Manufactured | 1.42 | 12.0 | 0.027 | 0.69 | | |
| Metric | 1.00 | 7.0 | 0.43 | 0.43 | 0.15 | 0.020 |
| Customary | 0.394 | 17.8 | 0.0169 | 0.43 | 0.4 | 0.0008 |
| Manufactured | 1.01 | 18.0 | 0.016 | 0.41 | | |
| Metric | 0.71 | 9.0 | 0.40 | 0.56 | 0.3 | 0.012 |
| Customary | 0.0280 | 22.9 | 0.157 | 0.56 | 0.75 | 0.0005 |
| Manufactured | 0.72 | 22.0 | 0.017 | 0.60 | | |
| Metric | 0.50 | 12.0 | 0.33 | 0.66 | 0.4 | 0.012 |
| Customary | 0.0197 | 30.5 | 0.0130 | 0.66 | 1.0 | 0.0005 |
| Manufactured | 0.50 | 33.0 | 0.0135 | 0.68 | | |
| Metric | 0.36 | 16.0 | 0.26 | 0.72 | 0.6 | 0.010 |
| Customary | 0.0142 | 40.6 | 0.0102 | 0.72 | 1.5 | 0.0004 |
| Manufactured | 0.36 | 40.0 | 0.011 | 0.79 | | |
| Metric | 0.25 | 23.0 | 0.185 | 0.74 | 1.0 | 0.008 |
| Customary | 0.0098 | 58.4 | 0.0073 | 0.74 | 3.0 | 0.0003 |
| Manufactured | 0.25 | 60.0 | 0.007 | 0.72 | | |

TABLE 2.—*Continued*

| | WIDTH OF OPENINGS | MESH | WIRE DIAMETER | RATIO WIRE DIAMETER TO OPENINGS | TOLERANCES | |
|---|---|---|---|---|---|---|
| | | | | | Mesh | Diameter |
| Metric | 0.17 | 31.0 | 0.15 | 0.88 | 1.0 | 0.008 |
| Customary | 0.0067 | 78.7 | 0.0059 | 0.88 | 3.0 | 0.0003 |
| Manufactured | 0.17 | 80.0 | 0.00575 | 0.85 | | |
| Metric | 0.125 | 47.0 | 0.089 | 0.71 | 1.5 | 0.008 |
| Customary | 0.0049 | 119.4 | 0.0035 | 0.71 | 4.0 | 0 |
| Manufactured | 0.119 | 120.0 | 0.0036 | 0.77 | | |
| Metric | 0.088 | 67.0 | 0.061 | 0.69 | 2.5 | 0.005 |
| Customary | 0.0035 | 170.2 | 0.0024 | 0.69 | 6.0 | 0.0002 |
| Manufactured | 0.0089 | 170.0 | 0.0024 | 0.69 | | |
| Metric | 0.062 | 98.0 | 0.040 | 0.65 | 3.5 | 0.005 |
| Customary | 0.0024 | 248.9 | 0.0016 | 0.65 | 9.0 | 0.0002 |
| Manufactured | 0.061 | 250.0 | 0.0016 | 0.67 | | |

general scheme on which the standards are worked out but to wire diameters and tolerances. The fundamental data on standard sieves now in use by the Bureau of Standards are given in table 3. In this table the sieve number in the first column corresponds approximately to the number of meshes to the inch. The Bureau of Standards, however, lays stress on the necessity of considering diameters of openings and not meshes. The sieve numbers are to be considered as arbitrary designation numbers.

Arrangements were made by the Bureau of Standards to test sieves and to certify and stamp with the seal of the Bureau those found to be satisfactory.

The Committee recommended methods for making separations and determining sizes of separations that are essentially those recommended in the original Hazen procedure.

The committee considered the feasibility of adopting a table of relations between sizes of sieve opening and sizes of sand grains separated by them to be used with standard sieves and presented table 4 as representative of observed facts, but the committee could not reach an accord on factors to be recommended to the Association.

The committee was divided on the question of designating the size of sand grain by giving the sieve opening or by giving the

TABLE 3

*United States standard sieve series table of fundamental data, standard specifications for sieves*

| SIEVE NUMBER | SIEVE OPENING | | WIRE DIAMETER | | TOLERANCE | | |
|---|---|---|---|---|---|---|---|
| | Millimeters | Inches | Millimeters | Inches | In average opening | In wire diameter | In maximum opening |
| | | | | | *per cent* | *per cent* | *per cent* |
| 2½ | 8.00 | 0.315 | 1.85 | 0.073 | 1 | 5 | 10 |
| 3 | 6.73 | 0.265 | 1.65 | 0.065 | 1 | 5 | 10 |
| 3½ | 5.66 | 0.223 | 1.45 | 0.057 | 1 | 5 | 10 |
| 4 | 4.76 | 0.187 | 1.27 | 0.050 | 1 | 5 | 10 |
| 5 | 4.00 | .157 | 1.12 | 0.044 | 1 | 5 | 10 |
| 6 | 3.36 | 0.132 | 1.02 | 0.040 | 1 | 5 | 10 |
| 7 | 2.83 | 0.111 | 0.92 | 0.036 | 1 | 5 | 10 |
| 8 | 2.38 | 0.0937 | 0.84 | 0.0331 | 2 | 5 | 10 |
| 10 | 2.00 | 0.0787 | 0.76 | 0.0299 | 2 | 5 | 10 |
| 12 | 1.68 | 0.0661 | 0.69 | 0.0272 | 2 | 5 | 10 |
| 14 | 1.41 | 0.0555 | 0.61 | 0.0240 | 2 | 5 | 10 |
| 16 | 1.19 | 0.0469 | 0.54 | 0.0213 | 2 | 5 | 10 |
| 18 | 1.00 | 0.0394 | 0.48 | 0.0189 | 2 | 5 | 10 |
| 20 | 0.84 | 0.0331 | 0.42 | 0.0165 | 3 | 5 | 25 |
| 25 | 0.71 | 0.0280 | 0.37 | 0.0146 | 3 | 5 | 25 |
| 30 | 0.59 | 0.0232 | 0.33 | 0.0130 | 3 | 5 | 25 |
| 35 | 0.50 | 0.0197 | 0.29 | 0.0114 | 3 | 5 | 25 |
| 40 | 0.42 | 0.0165 | 0.25 | 0.0098 | 3 | 5 | 25 |
| 45 | 0.35 | 0.0138 | 0.22 | 0.0087 | 3 | 5 | 25 |
| 50 | 0.297 | 0.0117 | 0.188 | 0.0074 | 4 | 10 | 40 |
| 60 | 0.250 | 0.0098 | 0.162 | 0.0064 | 4 | 10 | 40 |
| 70 | 0.210 | 0.0083 | 0.140 | 0.0055 | 4 | 10 | 40 |
| 80 | 0.177 | 0.0070 | 0.119 | 0.0047 | 4 | 10 | 40 |
| 100 | 0.149 | 0.0059 | 0.102 | 0.0040 | 4 | 10 | 40 |
| 120 | 0.125 | 0.0049 | 0.086 | 0.0034 | 4 | 10 | 40 |
| 140 | 0.105 | 0.0041 | 0.074 | 0.0029 | 5 | 15 | 60 |
| 170 | 0.088 | 0.0035 | 0.063 | 0.0025 | 5 | 15 | 60 |
| 200 | 0.074 | 0.0029 | 0.053 | 0.0021 | 5 | 15 | 60 |
| 230 | 0.062 | 0.0024 | 0.046 | 0.0018 | 5 | 15 | 60 |
| 270 | 0.053 | 0.0021 | 0.041 | 0.0016 | 5 | 15 | 60 |
| 325 | 0.044 | 0.0017 | 0.036 | 0.0014 | 5 | 15 | 60 |

*Note:* In order to utilize cloth now on the market, it will be permissible, until further notice is given to the contrary, to use wire whose diameter is within a tolerance of 10 per cent for the first three groups and 20 per cent for the last two groups. Until notice is given to the contrary, the allowable tolerances on average openings will be 50 per cent more than those given in the above table.

mean diameter in millimeters using in the latter case Hazen's method for calibrating sieves. The committee in general felt that further investigation was necessary to reach a conclusion on this point.

Since the report of the Committee on sand analysis in 1918 it does not appear that the standard sieves recommended by the U. S. Bureau of Standards have come into very general use, though firms like the W. S. Tyler Co. of Cleveland, Ohio are prepared to make them. Generally there has been a tendency to adhere to the manu-

TABLE 4

*Relations between sizes of opening and sizes of separation of sieves*

| SIEVE OPENING | MESH | RATIO WIRE DIAMETER TO OPENING | RATIO SIZE OF SEPARATION TO OPENING | CORRESPONDING SIZE OF SEPARATION |
|---|---|---|---|---|
| *mm.* | *inches* | | | *mm.* |
| 8.00 | 2.54 | 0.25 | 1.09 | 8.72 |
| 5.66 | 3.56 | 0.26 | 1.09 | 6.17 |
| 4.00 | 5.1 | 0.25 | 1.09 | 4.36 |
| 2.83 | 7.0 | 0.29 | 1.09 | 3.08 |
| 2.00 | 9.9 | 0.28 | 1.09 | 2.18 |
| 1.41 | 12.7 | 0.42 | 1.10 | 1.55 |
| 1.00 | 17.8 | 0.43 | 1.10 | 1.10 |
| 0.71 | 22.9 | 0.56 | 1.10 | 0.78 |
| 0.50 | 30.5 | 0.66 | 1.10 | 0.55 |
| 0.36 | 40.6 | 0.72 | 1.11 | 0.40 |
| 0.25 | 58.4 | 0.74 | 1.11 | 0.28 |
| 0.17 | 78.7 | 0.88 | 1.11 | 0.19 |
| 0.125 | 119.4 | 0.71 | 1.11 | 0.14 |
| 0.088 | 170.2 | 0.69 | 1.11 | 0.10 |
| 0.062 | 248.9 | 0.65 | 1.20* | 0.07 |

*Ratio assumed for twilled cloth. For plain cloth ratio is 1.11 and separation is 0.068 mm.

facturers standards that most nearly approach those of the Bureau of Standards and the standard sieves manufactured by the W. S. Tyler Co. are in fairly general use especially for the examination of concrete aggregates and they approximate closely the standard of the United States Bureau of Standards.

## PHYSICAL, CHEMICAL AND MICROSCOPIC ANALYSIS OF SAND

Within recent years more and more recognition has been given to the close relation between the condition of filter sand and the be-

havior of filters and this in turn has given rise to the periodic examination of filter sand comprising the usual mechanical, physical, mineral and organic chemical, and microscopic analyses.

The mechanical analysis is of value in determining change in size of sand due to losses of fine material during washing and the effect of incrustation due to lime, iron and manganese.

The physical analysis by an observation of color, odor, shape of grains and shrinkage gives considerable information on the condition of the sand beds including incrustation and organic growths.

Mineral chemical analysis brings out the nature of incrusting materials.

Organic chemical analysis would give a measure of the extent of organic growth within the bed and a measure of the effectiveness of cleansing methods.

The recent investigations of John R. Baylis at the Montebello filters in Baltimore have emphasized the importance of microscopic analysis as throwing light on the condition of a filter bed. This gives a measure of the thickness of gelatinous films on sand grains which appear to bear an intimate relation to the behavior of mechanical filters. According to studies by Baylis, a certain amount of this organic growth is necessary to efficient filtration, while too much gives rise to crack formation and clogging.

The committee has not had an opportunity to study and compare methods that have been employed in making physical, chemical and microscopic analyses, but hopes this progress report will stimulate discussion and bring to the committee material which it may use in formulating suggested standard methods.

## REPORT OF STANDARDIZATION COUNCIL

The fourth year of activities of the Standardization Council shows sufficient material in hand and available in the early future for the preparation of the first edition of a Manual of American Water Works Practice. Accordingly the Council has requested authority of the Executive Committee for the execution of a contract with the publishers of the JOURNAL, the Williams & Wilkins Co. of Baltimore, for the publication of the proposed manual.

After the material has been prepared, there will be no expense to the Association, unless alterations in the proof result in costs in excess of 10 per cent or the cost of setting up the original composition. All costs of such additional changes in the proof, as is the ordinary custom, will have to be paid by the Association. The publishers agree to pay the Association a royalty of 10 per cent of the price received by them for each copy sold. It is expected that the Council in cooperation with the Publication Committee can get the manuscript completed early in 1925.

As to carrying out the recommendations of our Committee on Standard Methods of Water Analysis for having the next edition of "Standard Methods of Water Analysis" published jointly by the American Public Health Association and the American Water Works Association, a form of contract has been approved by the committees of the two Associations and has recently been put before the respective Executive Committees for official approval. The contract provides for the manuscript to be put in final form acceptable to the committees of the two associations and then be turned over to the general secretary of the American Public Health Association to supervise printing and binding. Copies will be placed on sale in the offices of the secretaries of the two associations at a price to be agreed upon and there is to be an equal division between the two associations both of total disbursements and of total receipts.

During the past year committees have been active in preparing material for reports, but the discussion of the material offered by and through the committees has been much less extensive than is

necessary in order to stimulate the committees in their activities. Indeed, in order to get the manuscript in satisfactory form for the proposed Manual, it is highly important to secure the benefits of extended discussion, which it now seems can be best managed by having certain topics discussed at meetings of the local sections in accordance with a program to be developed jointly by section committees, the Publication Committee and the Standardization Council.

With sessions only four days per year for an Association dealing with the many topics involved in water works practice, the conviction has become most pronounced that the growth of the Association demands new machinery for securing adequate discussion.

We shall review briefly the status of activities of our several committees.

### COMMITTEE 1. STANDARD METHODS OF WATER ANALYSIS

The status of this committee's activities is shown in the JOURNAL, September, 1923, page 861. Each member of the committee has received definite assignments of topics for individual study and investigation. The work of coördinating views with the committee of the American Public Health Association is to be paralleled in some particulars by cooperative work with a committee of the Society of American Bacteriologists.

### COMMITTEE 2. STANDARDS FOR SATISFACTORY DRINKING WATER

The activities of this committee are controlled by the Advisory Committee on Official Water Standards of the United States Public Health Service of the Treasury Department. Much information on this subject was gathered by this committee and presented at the Detroit convention and summarized in the JOURNAL, September, 1923, page 884.

### COMMITTEE 3. PRACTICABLE LOADINGS FOR PURIFICATION PROCESSES

To this committee has been assigned one of the leading topics in the field of water treatment. The committee has prepared ample material on important topics for wide and fruitful discussion.

### COMMITTEE 4. COLLOID CHEMISTRY IN RELATION TO WATER PURIFICATION

This committee reported in the JOURNAL, March, 1922, page 273, a summary of prevailing views as to the applicability of hydrogen

ion tests and the practical benefits arising from information so secured. To carry the information beyond this point, the subject must have comprehensive yet detailed discussion by committee members and other interested workers.

### COMMITTEE 5. WATERSHED PROTECTION

This committee provides valuable information for discussion both in its report in the JOURNAL for May, 1923, page 453 and in the JOURNAL for May, 1924. Experiences in the protection of the Catskill Watershed of the city of New York will also be offered in a separate paper.

### COMMITTEE 6. INDUSTRIAL WASTES IN RELATION TO WATER SUPPLY

Information of much practical benefit was offered by the committee at the last two conventions and summarized in the JOURNAL for May, 1923, and further information indicating experiences in remedial steps appears in the JOURNAL for May, 1924. This topic is particularly one upon which discussion is needed to bring out information of importance, not known as widely as should be the case to those in charge of water supply works.

### COMMITTEE 7. PUMPING STATION BETTERMENTS

This committee continues to supply articles on new equipment and improved arrangements and operating schedules. The papers for the year include information on the selection of auxiliaries for steam-operated stations, in the March, 1924, JOURNAL, and the contribution on the selection of motor-driven pumps at Kansas City described in the JOURNAL for May, 1924.

### COMMITTEE 8. PHYSICAL STANDARDS FOR DISTRIBUTION SYSTEMS

This committee offers a paper by V. Bernard Siems and D. Benton Biser on "Fire Protection Requirements in Distribution System Design" in the JOURNAL for January, 1924, for discussion, and it is expected that fire protection aspects will be discussed by members who specialize in such topics.

### COMMITTEE 9. STANDARD SPECIFICATIONS FOR CAST IRON PIPE AND SPECIALS

This committee is dealing with the question of improved coating for pipe and awaits information from the manufacturers. Lack of funds restrains activities in carrying out experimental work needed to formulate improved standards.

### COMMITTEE 10. STANDARDIZATION OF SERVICES

This committee offers for discussion, a contribution on the Action of Water on Service Pipes, in the JOURNAL for May, 1924.

### COMMITTEE 11. SANITARY FOUNTAINS

A final report has been prepared appearing in the JOURNAL, March, 1924. It recommends the adoption of specifications as stated and the promotion of information relative to more adequate regulation and supervision of this feature.

### COMMITTEE 12. TESTING OF WATERWORKS MATERIALS AND SUPPLIES

This committee offers for discussion several topics, including proposed specifications for chemicals required for water purification, as set forth in the JOURNAL, May, 1924.

### COMMITTEE 13. METHODS AND RECORDS OF WATER WASTE CONTROL

This committee made a comprehensive report, printed in the JOURNAL, May, 1923. This report awaits further discussion and especially response to the request for information made by the committee in the JOURNAL for January, 1924. As soon as the committee receives the benefit of the discussion needed, it will prepare its final report.

### COMMITTEE 14. COMMITTEE ON METER RATES

The final report was accepted by the Association at the Detroit convention, as stated in the JOURNAL, September, 1923.

### COMMITTEE 15. PRACTICAL STANDARDS OF RULES AND REGULATIONS OF RELATIONS BETWEEN WATERWORKS AND CONSUMERS

This committee has gathered a fund of information on this subject, which it is now engaged in condensing for publication.

### COMMITTEE 16. ESSENTIAL DATA FOR WATER RECORDS AND REPORTS. (A) MUNICIPAL PLANTS; (B) PRIVATELY-OWNED PLANTS

This committee has prepared forms for records and reports which will serve as an excellent basis for promoting discussion on how to improve forms earlier recommended and in use by many water works. This undertaking requires coördination with the representatives which, at our request, were appointed by the New England Water Works Association as well as with the activities of other committees appointed by the Standardization Council.

### COMMITTEE 17. STEEL PIPE LINES

This committee has not yet sent material to the Council for its consideration.

### COMMITTEE 18. FILTER SAND, TESTING AND RECORDING

This committee offers its first progress report for discussion; it will be found in the JOURNAL, May, 1924.

While the most important feature to stress by Council is to urge the support of the Association to discussion of reports of these committees, it is a pleasing task for the Council to record its appreciation of the active work done by and for the great majority of its committees. As was anticipated some of the members have not been able to render the service expected and, regardless of cause, it will be necessary to make some changes in personnel following the next convention.

The personnel of Council during the fourth year of service has been as follows:

Chairman, George W. Fuller, New York; George A. Johnson, New York; Frank A. Barbour, Boston; Edward Bartow, Iowa City; W. W. DeBerard, Chicago, and Malcolm Pirnie, Secretary, New York.

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# A DEVELOPMENT PROGRAM FOR THE AMERICAN WATER WORKS ASSOCIATION

By George W. Fuller[1]

Instead of a presidential address, the writer proposes to review somewhat briefly some of the more important features which have come to his attention during the year when he has had the honor of being the president of this Association.

The past year has been one of substantial growth in many ways. The membership in good standing on April 1, 1924, was 1936, a net increase for the fiscal year of 224, which compares very favorably with any previous year.

The resignation of John M. Diven, our active secretary, has been the principal event. At a meeting of the Executive Committee, January 18, 1924, he was made secretary emeritus,but since February 1 he has continued as advisor to Mr. W. M. Niesley, and in helping the Association in every way feasible within the time at his disposal.

One who has not been an officer of this Association cannot possibly appreciate the benefits which have been derived by the organization from the activities of Mr. Diven. He was president in 1892; secretary and treasurer from 1902 to 1912; secretary and editor from 1913 to 1916; and secretary from 1917 to February 1, 1924. This period of unflagging service on his part was during one of limited resources for a struggling association. It is significant of the man's interest in this society that every item of office equipment in the office of the secretary, with the exception of one typewriter, has been furnished by him, at his own expense. From all over the country requests have come from the members that some recognition be given to Mr. Diven to record their appreciation of his services, in addition to the formal resolutions adopted by the Executive Committee, as set forth on page 490 of the Journal of March 1924. It is with great pleasure that the officers have arranged for a Testimonial Dinner to be given to Mr. Diven on the evening of May 19, 1924.

[1]Retiring President, American Waterworks Association, 1923–24. Consulting Engineer, New York, N. Y.

The offices of the Secretary at 153 West 71st street, which were established in 1919, when downtown offices in New York were unobtainable, were given up on March 1, 1924. This was caused primarily by notice of increased rent. Two small rooms, numbers 1012-13 at 170 Broadway, were rented until May 1, 1925. They have been fitted in a modest way for carrying on the affairs of the Association.

The finances of the Association are in a sound condition. The budget for the past fiscal year, $23,000, was not all used, according to the unaudited figures now available, largely on account of the saving in the estimated expenses for committee work. The actual disbursements were $21,915.27 as compared with total income for the fiscal year of $26,117.31. This left us on April 1, 1924, with a cash balance of $4,202.04 as compared with a cash balance of a year ago of $3,934.40. The invested funds of the Association consist of $12,000 of United States and Canadian Government bonds.

The JOURNAL for the year 1923 consisted of a volume of 1187 pages, issued in six numbers. The quality of the material reflects credit upon the Association and particularly upon the committees and the editor. It attracts favorable attention throughout this country and abroad.

The most serious difficulty with the JOURNAL is that, with a printing budget of $10,000, it is not possible to print all the material that comes to the Publication Committee, which is furthermore in the embarrassing position of not being able to invite papers from the local section meetings as should, and would be done, if funds for printing them were available.

In the beginning of this year there were 37 papers in the hands of the editor, exclusive of those committee reports or papers in the hands of the Standardization Council and the Publication Committee for the convention in May of this year.

The work of the Standardization Council has developed to a stage where the reports of its committees need further discussion in order to bring out their value and supplement them with comments widening their field of usefulness. A serious situation confronts the Association in this problem of developing a program by which adequate discussion may be secured. This is particularly important for the preparation of material needed for the proposed Manual of Practice for Water Works, described in the report of the Standardization Council.

It is not feasible to get needed discussion during the four-day convention held once each year. It is imperative that local sections be called upon to discuss committee reports and test their soundness or weakness by the judgment of members of this Association throughout the entire country. This can be arranged by coördinating the efforts of the Standardization Council, the central Publication Committee and the local Program Committees for the various local sections. This must be done without delay if the proposed Manual is to be sent to the printer during the coming year.

In earlier years, limited finances curtailed many activities. Fortunately that burden is not so pressing now with increased membership and with the increase in advertising rates and in number of advertisers as a result of activities during the past year.

It is estimated that income from operations during the coming fiscal year will amount to about $26,000 which with a $4000 cash balance would make $30,000 available for budget requirements without drawing on the permanent funds of the Association. Indeed, several believe that increased growth of the Association would make feasible a budget in excess of $30,000.

Our publications are now becoming too bulky to be bound as a single annual volume and the Publication Committee is seriously considering issuing eight numbers of the JOURNAL per year in two volumes of four numbers each. This it is feasible to do by increasing the printing budget from $10,000 for the past year to about $13,500. There will be some added expense, but it will afford the Association the opportunity of deriving more income from advertising, for our rates are such that many of our advertisers would undoubtedly wish to utilize their advertising space in eight rather than six numbers per year.

As to a Decennial Index, the indications are that this is not needed by more than about three or four hundred members. As its net cost would exceed some $2000, it is thought best to put available funds into the increased number of journals per year, particularly as that seems necessary in order to develop the discussions insisted upon by the Standardization Council before it releases material for he pro po sed Manual.

### COÖPERATIVE UNDERTAKINGS

The report of the Standardization Council shows that progress has been made in the matter of Standard Methods of Water Analysis

in undertaking the next edition jointly with the American Public Health Association.

Along this branch of our activities practical plans are under discussion for coöperating with the Society of American Bacteriologists. The same is true of coöperative committee work in the matter of purification of boiler waters in conjunction with the work now in hand by the National Electric Light Association.

Steps have been taken to establish gradually more practically effective coöperation between the American Water Works Association and the National Fire Protection Association on matters of common interest and along lines of effective mutual benefit.

The American Committee on Electrolysis has not been particularly active recently and resumption of activities depends essentially on whether the 11 participating associations, including the American Water Works Association, are agreeable to continuing this committee and a research sub-committee and to provide the latter with adequate funds, meaning a pledge from our Association to contribute $2500 per annum for two years. Messrs. E. E. Minor and N. S. Hill, Jr. are in favor of continuing this joint undertaking by having it endorsed by the Executive Committee at the May meeting and with the understanding that the needed funds will be arranged for by our representatives through subscriptions by interested water companies and city water departments. I endorse the judgment of Messrs. Hill and Minor.

The New England Water Works Association has promptly responded to invitations to appoint representatives on the committees of our Association, particularly on Water Meters, Meter Rates and Essential Data for Water Records and Reports. Your president believes that these coöperative arrangements should be continued and strengthened along lines of mutual benefit to all concerned.

## COMMITTEE REPORTS

Most of the committees not operating under Standardization Council seem to have proceeded as far as they are able to do pending the development of new evidence or new circumstances surrounding their activities.

In regard to the Committee on Standard Form of Contract, their activities have still continued in conjunction with representatives of other Associations. Their progress report was presented a year

ago and real benefit has been derived from its use in preparing the forms of contract in use on the water extensions and betterments at Kansas City and elsewhere.

All of these committees should be continued with the understanding that they are to report their accomplishments as promptly as as new developments occur.

### REORGANIZATION TO PROMOTE DISCUSSION

From what is said above, it is clear that the Standardization Council will proceed with the proposed Manual of Water Works Practice, if committee reports and other material are adequately discussed during the coming year, but not otherwise.

Fortunately, the financial affairs of the Association permit the central organization to print discussions developed by the meetings of local sections: and can now provide for at least some stenographic reports of the discussions at section meetings. Therefore it is desirable to have closer coöperation between the Standardization Council and the central Committee on Publications on the one hand, and those in charge of local section meetings, on the other hand. This would be a decided step forward, and should bring added strength to the Association through the interest in its general affairs by members who are seldom able to attend the annual conventions.

The use of Monday of convention week for group and committee meetings will do much toward crystallizing views as to procedure along many lines of activity. Where necessary, stenographic services will be provided for committees and groups ready to prepare and submit to the Association formal statements on pending matters of importance originating either with the officers of the Association, or developing from views exchanged at round table talks.

These steps are perhaps scarcely to be designated as reorganization steps, for they are simply the normal outgrowth of what has been occurring for several years, but with progress hampered through inability of the central organization to provide facilities, such as stenographic services, for various detached meetings, and particularly to coördinate efforts between the central officers and those in local charge of section meetings, group meetings or committee meetings.

NATIONAL DIVISIONS

While development along the lines above indicated will be of real benefit in making the Association grow and retain its place as the leading organization of its kind in this country, it does not deal with two other difficulties.

One of these relates to the fact that the programs of the annual conventions for some time have been materially overcrowded and that there has been insufficient time for discussing the superabundance of good material offered.

The second difficulty with the central organization is that responsibility for its accomplishments in the past has all fallen upon the shoulders of too few individuals.

Coördination between the central offices and the local sections throughout the country will remedy past difficulties in part, but they will not deal adequately with the overcrowded programs at the annual convention.

Experience has demonstrated, as at the Detroit convention, that it is perfectly feasible to conduct two enthusiastic meetings at the same time; one dealing with purification matters and the use of laboratory methods for controlling their performance and the other group dealing with the more practical subjects from the viewpoint of the superintendent.

It is along that line that the Association must develop through the formation of national divisions or groups, having special interest in certain branches of water works practice.

To put this suggestion into effect is not particularly simple because of the wide diversity of viewpoint from practical experience to be found among our membership and with the perfectly human viewpoint by each group that their own activities are of outstanding importance.

There is no reason why the superintendents should not be offered full facilities for conducting meetings dealing with topics of special interest to them. Correspondingly, there is no reason why laboratory men should not have an opportunity at annual conventions to discuss matters of a strictly laboratory nature and then, in conjunction with other groups of members, participate in the discussion of topics related to the purification of water by natural agencies or by artificial methods and devices.

For some time there has not been great progress made in advancing a better understanding between fire protection engineers and agencies

and the waterworks men. This situation is unfortunate and will never grow better until opportunity is afforded to have the two groups of men get better acquainted and to discuss things with a view to coördinating opinions, harmonizing practical procedures and establishing a feeling that each group is endeavoring to make progress along the lines which will be of mutual benefit.

With approval of the Executive Committee at its meeting on January 18, 1924, your president appointed three committees to deal respectively with the development of more effective machinery and organization for increasing discussion of committee reports and of papers at the annual conventions. At the Executive Committee meeting discussion related to the establishment of three national divisions, as follows:

1. Plant Management and Operation Division.
2. Water Purification Control Division.
3. Fire Protection Division.

Discussion of these matters by correspondence has been adequate to reveal only the view that the matters should come up for thorough discussion at the next convention.

## NEED FOR AVOIDING ENCROACHMENT ON THE FIELDS OF OTHER NATIONAL ORGANIZATIONS

Since the war it has been apparent that several of the national technical and professional organizations have spread out in activities somewhat different than hitherto. The result is in some instances an unfortunate tendency to break away from the special fields earlier occupied and to duplicate the effort and scope of activities of others, even to the point of making what might be called encroachment on the well established fields of other organizations.

It is our thought that the activities of the American Water Works Association have been set along fairly definite lines, including the activities of its different groups from the administrative superintendent to the laboratory man, who seeks to use his technical knowledge as a means of controlling more effectively the arrangements in use for providing water of satisfactory quality.

We are thoroughly in accord with the policy of coöperation with other organizations dealing with matters of common interest. We think, however, that it is necessary for this Association to exercise care in seeing that it does not unreasonably encroach upon the fields

of others and at the same time use its influence to prevent other organizations encroaching upon the activities relating to water works practice, particularly from the standpoint of those who day by day are occupied with the operation of this type of utility in its various ramnifications.

### NEED OF AMENDING CONSTITUTION

This is a subject which will be discussed by the Executive Committee at the May meeting. It has in hand already the creation of nine rather than six districts as at present and the election of three instead of two trustees each year.

Another point is that we have a secretary emeritus who occupies that position now solely as an office title, but who by Constitution should have created for him such an official title. In the present instance, such an office should carry a membership on the Executive Committee in order that the benefits of Mr. Diven's long experience may be made available to the management of the Association as long as he is able to help us.

As to membership, Article III, Section 3, provides that an Active Member may be "any qualified person engaged in the advancement of knowledge relating to water supplies in general." Under Section 4, there should be a corresponding clause added to provide for Corporate Members, since we have recently taken in quite a number of state departments of health, fire insurance bureaus and industrial corporations maintaining relatively large water supply works for industrial or domestic purposes or both.

The selection of a place for the next convention has developed into a time-consuming farce which frequently does not represent the wishes of the membership. A majority vote can seldom be polled on the first ballot for one city, so that on the second ballot, limited to the two cities receiving the highest votes on the first ballot, the usual result is a scramble which may or may not record the real wish of the members present. The time has come when convention cities should be selected by the Executive Committee on the advice of the Convention Committee and preferably with a rotation to facilitate the attendance of members in different sections of the country.

The management of the Association in respect to coördination between the efforts of the central officers and those of sections or divisions should be clearly specified with reconsideration of the funds

which may be made available for the meetings of local sections or of national divisions if such should prove desirable or necessary in the opinion of the Executive Committee.

ACKNOWLEDGMENTS

I wish to take this opportunity to indicate my great appreciation of the coöperative effort of the officers and committees of the Association, without whose support little of our progress during the year would have been possible.

# DISCUSSIONS

## SELECTION OF AUXILIARIES FOR STEAM GENERATING PUMPING STATIONS[1]

While the experience of the writer in connection with pumping stations has been very limited, it would seem that practically all of the broad principles underlying the design and operation of steam electric generating stations might be applicable, particularly in so far as these principles cover the operation of the auxiliary apparatus within the plant. It would seem that the only real differences between the pumping station and the electric generating station are; first, the substitution of a pump and its speed reduction gear in place of the conventional electric generator; and second, the fact that it is undoubtedly often necessary or desirable to reduce the speed of the pump somewhat to take care of the varying demand for water. With the general increase in price of fuel as well as the increase of load factor on the newer generating stations and water pumping plants, increased capital cost can be justified by the attendant gains in economy. As these gains are mainly to be realized by increasing the pressure and temperature of steam supplied and expanding this steam to the maximum vacuum, it becomes more and more evident that the steam turbine will replace the reciprocating engine. Inasmuch as the temperature of the water handled by the main pumps is relatively cool, even in the more temperate climates, it is possible to realize, on the average, higher vacuum than is commercially obtainable in the larger electric generating stations. As this higher vacuum, as well as higher temperature of steam, can be used to greater advantage in steam turbines it would seem that the reciprocating engines should not be generally used in the larger stations.

The use of the steam turbine makes possible the fuller utilization of the various regenerative cycles which are coming into very general use in the modern central stations. In those plants of sufficient size to justify pumping units necessitating drives of from 400 to

[1]See paper by F. G. Cunningham, JOURNAL, January, 1924, page 341.

800 h.p., it would seem entirely practicable to use a steam pressure of at least 300 pounds gage and a total temperature of 600°F. For units larger than 800 h.p. one should easily be able to justify the use of steam at 375 pounds pressure with a total temperature of 700°F. Standard turbine units as built by any of the larger turbine manufacturers are designed for use under these maximum pressures and temperatures.

Where higher pressures and temperatures are resorted to, one is justified by going to stage-bleeding of the turbine which for smaller units should be limited to two-stage and for larger units three-stage bleeding where no economizers are to be used. Where the use of economizers is contemplated it is improbable that the use of more than two-stage bleeding can be justified, under which condition steam should be bled at such points as will most economically permit of the feed water being admitted to the economizers between the temperature of 200 and 220°F. Where no economizer is used one is justified in bleeding steam from the main turbine to heat the feed water, certainly to within 100° of saturated steam temperature. Where this practice is carried out the flue gas temperatures can be readily lowered to such a point as will produce an overall boiler efficiency of 80 per cent by the use of air pre-heaters, it being borne in mind that if boilers are to be fired by under feed stokers the air temperatures should probably not exceed 300°F. Where hand firing, oil, or pulverized coal is used, air temperatures up to 400°F. should cause no trouble. There are at the present time actual installations used in firing oil stills in which air temperatures approximating 500°F. have been used with success.

The use of high pressure, high temperature steam makes it highly undesirable to use any form of steam drive for auxiliary apparatus other than the air pumps. For air removal pumps there can be no choice from the standpoint of economy, reliability and maintenance cost in the use of other than the steam jet type, equipped with surface type inter and after condensers. The use of small turbines as generally built for non-condensing service on high temperature steam has been very unsatisfactory. This means that under this condition one is committed to the use of electric drive for auxiliaries unless some satisfactory arrangement can be made for the use of hydraulic drive. As between the use of electric and hydraulic drive the most efficient operation will undoubtedly always favor the former.

It now becomes necessary to provide a reliable source of auxiliary power which can undoubtedly be most satisfactorily and economically furnished by directly connecting a generator to each of the main pump shafts. These generators need normally be of only sufficient capacity to take care of the auxiliaries for each main unit, although one might feel justified in having them of sufficient capacity to supply power to the auxiliary drives of two main units, thereby insuring auxiliary power in the event of trouble in one of the direct connected generators; trouble of this nature, however, is exceedingly improbable. Where the main units are operated at or near constant speed, an A.C. auxiliary generator may be used, however, when it is considered that practically all of the auxiliary apparatus in connection with each unit is susceptible to increases in economy when the speed of the auxiliary drive is reduced as the load on the main turbine is reduced, one would be justified in using a D.C. generator and D.C. variable speed motors where the necessary range of speed variation may be obtained by field control. Where the speed of the main unit varies through a considerable range, the use of the D.C. auxiliary generator is obligatory as it may be equipped with a suitable voltage regulator to maintain a uniform voltage at the generator terminals throughout the entire speed range of the main turbine. Units of this type are especially reliable, as it would only be necessary to use a standard type of direct current generator of very moderate capacity, operating at a very satisfactory speed. The record of such units is all that can be desired and far exceeds that of the small steam turbines in reliability. It gives a very high economy as power is being obtained from the main turbines which is the most economical piece of apparatus in the station. The combined efficiency of the motors and the generator should be at least 85 per cent which means that power at the main turbine shaft is supplied to the shafts of the auxiliary apparatus at an efficiency of 85 per cent. This arrangement is extremely reliable as its reliability is almost entirely dependent on the reliability of the main pump drive, and if the main turbine fails the auxiliary power is not needed. It is very simple, all of the controls can be easily grouped at one central point, everything is readily accessible and where the motors are equipped with ball bearings there should be practically no maintenance, and the efficiency of the auxiliary power supply and auxiliary drives would be sustained at their original figure. The generator and motors will be particularly durable and should beyond doubt outlive the main apparatus.

It is only necessary to provide some form of drive to take care of starting up the plant when it is originally built, or should it ever become necessary to shut it down cold. This can best be taken care of by a single steam driven house turbo generator of sufficient capacity to put one main unit in service. This unit may be of slow speed and poor economy as it may reasonably be expected that it will not be called upon to operate more than a few hundred hours during the life of the plant.

While the above plan may seem revolutionary and may at first glance seem to be somewhat impracticable, a careful analysis of the factors involved will satisfy the most skeptical as to its reliability, economy, simplicity and general adaptability. It has stood the test of the scrutiny of a number of experienced and careful designers of large central station developments. It is now being installed on a 40,000 kilowatt development and has been adopted for a new development of 120,000 kilowatts in Baltimore and will very shortly be in service in at least one other large central station plant in the United States.

A. L. Penniman, Jr.[2]

I question whether the paper[1] by Mr. Cunningham has sufficiently stressed the advantages of motor driven auxiliaries for use in steam operated pumping stations, and I am quite sure that Mr. Cunningham has very much understated the reliability of motor driven auxiliaries for use in pumping stations. Few classes of equipment require a greater degree of reliability than do the auxiliaries of a large steam electric generating station. The trend at the present time in the design of new generating stations is all in the direction of eliminating the small steam driven auxiliaries and substituting in their place motor driven auxiliaries. The reasons for this trend should be of interest to the man who is designing a steam operated pumping station, as to some extent the same problems are to be faced in the design of a steam operated pumping station which supplies water to a city water system as have to be dealt with in connection with the design of a steam electric generating station.

There has been a general feeling in the past on the part of steam station engineers that for those auxiliaries requiring the maximum

[2]General Superintendent, Consolidated Gas, Electric Light and Power Co., Baltimore, Md.

degree of reliability, turbine drive or steam engine drive should be used in all cases. As steam pressures and steam temperatures have been increased, it has been more and more difficult to design small turbines and engines for auxiliary drive which would operate satisfactorily with the higher steam pressures and temperatures. Operating troubles and high maintenance in connection with these auxiliaries have increased rapidly as higher steam pressures and temperatures were used. In connection with many of the steam driven auxiliaries it was necessary to insert a reduction gear between the turbine and the pump or fan which the turbine was driving. It is coming to be pretty generally recognized by steam station engineers that reduction gears are good things to eliminate wherever possible. Another factor working in the same general direction has been recognition of the advantages of variable speed drive in connection with the operation of many of the auxiliaries. This variable drive is best obtained by means of a direct current motor. It may be obtained in connection with a steam turbine, a steam engine, or a water turbine, but it is well to bear in mind that the efficiency of a steam turbine or a water turbine drops off very rapidly as the speed is decreased and the ratio of blade speed to steam speed or water speed is changed. This drop in efficiency actually defeats one of the main objects of variable speed drive, which is a proportioning of the power required for the auxiliaries to the load which is being carried by the station.

It is well to bear in mind that in connection with forced or induced draft fans in the boiler room, and in connection with circulating pumps in connection with the surface condensers, the speed of the auxiliary may be varied almost directly with the load which is being carried by the main equipment, a boiler in one case and a turbine in the other. The shaft horse power delivered to the auxiliary varies as the cube of the speed. Now, if such an auxiliary, whether it be a forced draft fan, an induced draft fan or a condenser circulating pump driven by means of a variable speed direct current motor with feed control, the electrical input to the motor will vary as the cube of the speed. The efficiency of this motor is almost constant throughout a reasonably wide range of speed variation. Another alternative is to drive such auxiliaries by means of variable speed, wound rotor induction motors. In this case, however, the efficiency of the motor drops off as the speed is decreased. Actually, this will result in the electrical input to the wound rotor induction motor varying as the square of the speed, although the shaft horse power

output of the motor to the auxiliary will vary as the cube of the speed. It is probable that, even in connection with the wound rotor induction motor, the average efficiency throughout the range of speed variation required for the auxiliary will be very much better than will be the efficiency of the steam turbine or the water turbine. Another factor which is causing the displacement of steam driven auxiliaries by motor driven auxiliaries in steam electric power stations is the desire on the part of steam station men to do away with all small steam piping and the multitude of small steam valves in connection with which a good deal of maintenance work has to be done. Obviously, this problem of high maintenance and steam leakage in connection with small valves and small steam piping becomes more acute as the steam pressure and steam temperature are increased

While fully realizing all the factors referred to above, engineers responsible for the design and operation of steam electric generating stations were unwilling to go to the use of motor driven auxiliaries until they would be assured that these motor driven auxiliaries would be reliable. Several different solutions have been worked out to insure the reliability of power supply for the motor driven auxiliaries. The steam driven house turbine appeared a few years ago to be one of the most promising solutions, and is still being used in connection with a number of the large steam generating stations which are being built. Another solution which seems even more promising, however, is the use of a separate generator, either A.C. or D.C., on the same shaft with the main turbine and the main generator; and it is this arrangement which seems to me to offer the best solution for the operating problems which are met with in connection with the steam pumping station.

I am assuming that we have under consideration a steam pumping station of moderate size, in connection with which the main pumps will be driven by means of steam turbines which will be at least 1000 h.p. in capacity. I believe that the most satisfactory arrangement in connection with such a station will be as follows:

Each of the main turbine driven pumps should be equipped with a direct current generator mounted directly on the end of the pump shaft. This direct current generator would run at the same speed as the pump, but should preferably deliver this power at a voltage of 250. All of the auxiliaries in the station, with the exception of the air removal pumps, should be driven by means of direct current motors. The

circulating pumps, the boiler feed pumps, the stoker motors and the motors driving the forced and induced draft fans should be arranged for a moderate variation in speed by a field control. No fuses should be used in any of the auxiliary circuits. Relays, if used at all, should be set high so as to function only in connection with the segregation of defective apparatus from the rest of the auxiliary system. In the event that there are two or more main pumping units in the station, it will be advisable to divide up the auxiliaries into two groups and drive each of the two groups by means of the direct current generator in connection with one of the two pumping units. In this way, any trouble which arises in connection with a piece of auxiliary equipment will at the most cause a disturbance in connection with the other auxiliaries which are supplied with power from the one generator tied in with that particular circuit.

It will be necessary to make a provision for starting up the station in the event of a total shut down, or in the event that the station is to be started after it has been out of service and cold for some time. Two possibilities suggest themselves in connection with this layout. One is to install a storage battery which will supply power to the auxiliaries during the period that steam pressure is being raised in the boiler house and the first one of the main pumping units is being brought up to speed. It is well to bear in mind that vacuum can be established preparatory to bringing the turbine up to speed with the use of very little auxiliary power. That is, under this condition of operation, the circulating pump may be operated at approximately 50 per cent of its maximum speed. A second solution for the same problem is to install a small steam driven direct current generator which will supply power for the auxiliaries during the period that the station is being started up. The turbine or engine driving this auxiliary direct current generator may be non-condensing and exhaust to atmosphere, as it will be in operation at a very small per cent of the total hours in the year. Provision will be made so that power may be supplied to the auxiliaries by means of this generator during the period that they are being started up. This latter arrangement has the disadvantage that it is necessary to establish steam pressure in the boiler house before the steam driven auxiliary generator is available for use. Of course, this same disadvantage is inherent in all steam driven auxiliaries. The first arrangement which I suggested, in which a storage battery is used for supplying power to the auxiliaries while the main equipment is being brought up to speed,

has the advantage that it is not dependent on the establishment of steam pressure in the boiler house. The stoker motors and the forced draft fans could be operated, taking power from the storage battery during the time while the steam pressure is being established.

In general, I think it will be found that the speeds at which the main pumps in good sized steam driven pumping stations are operated will be suitable for the operation of direct current generators mounted on the shaft with the main pump. These direct current generators will be quite similar in character to the direct connected exciters which have been used for a good many years in connection with turbo-generators, as a means of supplying the field excitation for

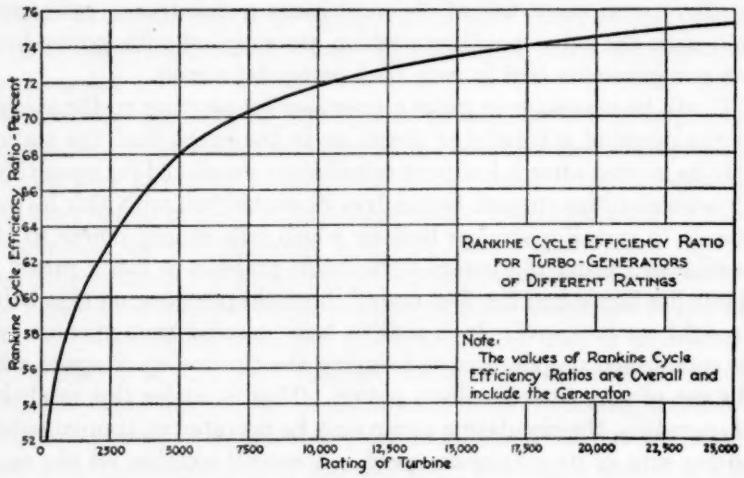


FIG. 1

the main generator. Few pieces of equipment in power stations have given more uniform satisfaction and have a better record for reliability than these direct connected exciters.

The question may be raised—"How do you expect to heat the feed water, if all of the auxiliaries are to be driven by means of direct current motors deriving their power from a generator mounted on the shaft of the main pumping unit?" The answer to this is, that we will bleed steam from the turbine driving the main pump. The Rankine Cycle efficiency ratio of this main pumping unit will probably be of the order of 60 per cent. The Rankine Cycle efficiency ratio of small turbines which would be used for driving the auxiliaries is very much lower. I am giving herewith a curve, figure 1, which

shows the over-all Rankine Cycle efficiency ratio for turbo-generators of different sizes. Bearing in mind that the Rankine Cycle efficiency ratio is the actual useful work performed by the turbine expressed as percentage of the useful work which would be performed by an ideal turbine having no losses, it is to be seen from this curve that the small turbines which would be used for driving auxiliaries must in the nature of the case be quite inefficient. The ideal thing, therefore, is to generate all the power by means of the prime mover which has the highest Rankine Cycle efficiency ratio, and that prime mover happens to be the main turbine which drives the main pump. The efficiency of the direct current generator which supplies power to the auxiliaries will be of the order of 92 per cent, and the efficiency of the motors which drive the auxiliaries will be of the order of 89 per cent, so that actually 82 per cent of the total power delivered by the shaft of the main turbine to the direct current generator will in turn be delivered as shaft horse power available for driving the auxiliaries.

In figure 2 I am showing a layout which I believe is well adapted for use in connection with the pumping station having one or more centrifugal pumps driven by means of steam turbines having a capacity of approximately 1000 h.p. each. I have indicated that steam will be bled out of the main turbine at two different pressures—8 pounds per square inch absolute and 36 pounds per square inch absolute. This steam will go to small closed heaters through which the condensate from the main condenser will be circulated. As the steam passes through the first closed heater, it will be raised to a temperature of 178°. As it passes through the second closed heater it will be raised to a temperature of 256°. It is to be noted that the amounts of steam going to each of the two closed heaters are substantially the same. Each of these two closed heaters are really small surface condensers, in which condensate is used as circulating water. It is to be noted that, with full load on the turbine, the operating condition which will exist the bulk of the time, one of these closed heaters will operate at a pressure somewhat above atmospheric pressure and the other heater will operate at a pressure somewhat below atmospheric pressure. The steam which is condensed in the high pressure heater will be trapped back into the low pressure heater, where a portion of it will flash into steam, but will be recondensed by the condensate passing through the low pressure heater. The combined drips from the high pressure and low pressure heaters will be trapped back into the hot well of the condenser after having passed

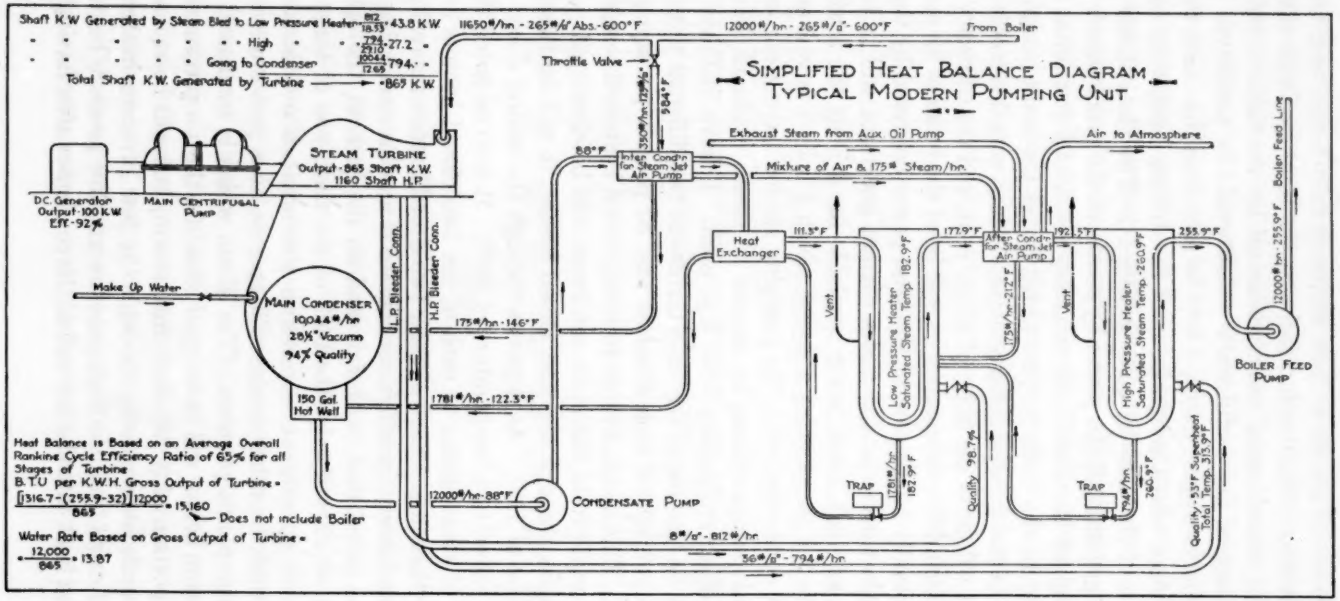
SIMPLIFIED HEAT BALANCE DIAGRAM
TYPICAL MODERN PUMPING UNIT
Shaft K.W Generated by Steam Bled to Low Pressure Heaters 812/18.53 = 43.8 K.W
High = 794/29.10 = 27.2
Going to Condenser 10044/12.69 = 794
Total Shaft K.W. Generated by Turbine = 865 K.W
11650#/hr - 265#/a² Abs. - 600°F
12000#/hr - 265#/a² - 600°F
From Boiler
Throttle Valve
350#/hr - 175#/a² - 584°F
STEAM TURBINE
Output - 865 Shaft K.W.
1160 Shaft H.P.
D.C. Generator
Output - 100 K.W.
Eff - 92%
MAIN CENTRIFUGAL PUMP
Exhaust Steam from Aux. Oil Pump
Air to Atmosphere
Mixture of Air & 175# Steam/hr.
88°F
Inter. Condtr. for Steam Jet Air Pump
Heat Exchanger
111.5°F
177.9°F
After Condtr. for Steam Jet Air Pump
192.5°F
255.9°F
Boiler Feed Line
12000#/hr - 255.9°F
Make Up Water
MAIN CONDENSER
10044#/hr
28½" Vacuum
94% Quality
L.P. Bleeder Conn.
H.P. Bleeder Conn.
175#/hr - 146°F
175#/hr - 212°F
Vent
Low Pressure Heater
Saturated Steam Temp. 182.9°F
High Pressure Heater
Saturated Steam Temp. 260.9°F
BOILER FEED PUMP
150 Gal. Hot Well
1781#/hr - 122.3°F
Heat Balance is Based on an Average Overall Rankine Cycle Efficiency Ratio of 65% for all Stages of Turbine
B.T.U per K.W.H. Gross Output of Turbine = [(316.7 - (255.9 - 32)] 12000/865 = 15,160
Does not include Boiler
Water Rate Based on Gross Output of Turbine = 12,000/865 = 13.87
12000#/hr - 88°F
CONDENSATE PUMP
TRAP
1781#/hr
182.9°F
Quality 98.7%
TRAP
794#/hr
260.9°F
Quality - 53°F Superheat
Total Temp. 313.9°F
8#/s - 812#/hr
36#/s - 794#/hr

FIG. 2

through a heat exchanger in which they will give up the bulk of their heat to the condensate on its way to the low pressure heater. Obviously, with the layout shown here, the greatest amount of available energy in each pound of steam will be abstracted and converted into useful work at the turbine coupling, for we are passing all of the steam through the main turbine which has a very much higher Rankine Cycle efficiency ratio than smaller steam turbines, which in an alternative layout might be used for driving the auxiliaries.

Another factor which is to be borne in mind is this: The cost per horse power of capacity in the turbine which drives the main pump is appreciably lower than is the cost per horse power in connection with small turbines which in an alternative layout would be used for driving the auxiliaries. The increase in the cost of the pumping unit incident to the use of a direct current generator mounted directly on the end of the pump shaft, and the use of the larger turbine which would be required to drive this generator in addition to the pump, will not be great. If we compare this layout for a moment with one in which we use water turbines to drive our auxiliaries, it is to be noted that we are decreasing the total capacity of the pumping station by the use of the water turbines driving the auxiliaries. The capacity of the pumping station is expressed in millions of gallons pumped daily. If we use an appreciable percentage of the water which is handled by the main pump in connection with the water turbines, we are decreasing the net capacity of the pumping station by just that much. I am of the opinion that, if all factors are taken into account, alternative designs laid down on the basis of electric drive for the auxiliaries along the lines which I have indicated, and water turbine drive for auxiliaries, and the total first cost of the station is placed on the basis of first cost per million gallons of water handled daily, the net capacity being taken, the layout with the electric driven auxiliaries will indicate the lower first cost.

I would make one exception to my general recommendation for the use of electrically driven auxiliaries, and that is in connection with the pumps which withdraw the air from the surface condenser. Efficient steam jet air removal pumps are available for this service. These steam jet air removal pumps are reliable, compact, require a minimum of attention, and are low in first cost. When all these factors are taken into account, it is questionable whether we can afford to install anything else than steam jet air removal pumps in connection with the main surface condensers.

It is to be noted that all of these recommendations which I have made make it possible to use a reasonably high steam pressure and temperature. If the steam piping is limited to the main leads between the boiler and the turbines driving the main pumps, the bulk of the small steam piping is eliminated, the number of valves is very much decreased, and it should be possible and economical in connection with the new pumping station to use a steam pressure as high as 250 pounds per square inch and a total steam temperature of 600°F. I would hesitate to recommend going higher than this in connection with the relatively small turbines which will be used in the majority of pumping stations.

I have made suggestions here which are in line with the trend in connection with design of modern steam electric generating stations. I am sure that, if these suggestions are embodied in the design of a pumping station, it will result in a real improvement in the over-all economy of the station without any sacrifice in its reliability. It is to be pointed out, however, that the over-all economy of the steam driven units of approximately 1000 h.p. capacity in a steam driven pumping station can never equal the over-all economy which is obtained in connection with a large steam electric generating station where single units of from 20,000 to 50,000 k.w. are installed. In many cases a careful engineering analysis will, I am sure, indicate that, even if the best possible design is laid down for the steam driven pumping station, the fixed charges and the operating costs of such a station will be higher than the fixed charges, the operating labor and the cost of purchased power in connection with an electrically driven pumping station taking its power from a large efficient steam electric generating station.

VERN E. ALDEN.[3]

## HYDROGEN-ION TESTS

The following simple procedure which has been found very satisfactory at Mt. Prospect Laboratory of the Department of Water Supply, New York City, should prove serviceable to smaller laboratories which cannot afford elaborate equipment. Procure from the Pyro-Electric Instrument Company, Chemical Division, Trenton, N. J., "Sterile Universal Buffer Solution M/10 concentration," also

[3] Assistant to General Superintendent, Consolidated Gas, Electric Light and Power Co., Baltimore, Md.

N/5 hydrochloric acid and N/5 sodium hydroxide, sterile and standardized by them. Follow their chart in making standards, 20 cc. volume, making them pH 0.2 apart. Procure brom thymol blue, powdered dye, from any of the firms supplying it for pH determinations. The preparation of the dye solution is as follows, according to Clark: Rub up a decigram of the dye in 3.2 cc. of N/20 sodium hydroxide. Dilute to 25 cc. with distilled water, making 0.4 per cent solution. Dilute again for use to 0.04 per cent solution. Add 1 cc. of the last to 20 cc. volume in making up the standards and solutions to be tested. Instead of using test tubes and a comparison block, it has been found convenient and apparently as accurate and less strain on the eye to make up these standards and solutions to be tested in sterile 2 ounce glass stoppered bottles, such as are used for the regular bacteriological samples. (These bottles are blown seamless and may be procured from Whitall-Tatum Co., New York City.)

The standards have been found to keep remarkably well. The original set made up by us two and a half years ago was recently replaced by a new set and the old standards were found not to have appreciably changed, indicating that the standards were well buffered, had kept well in the sterile bottles, that the glass of these is of excellent quality, and, a very important consideration, that the sterilized solutions furnished by the Company had likewise kept without appreciable change. These standards are checked by the firm electrolytically. We had no means of testing the accuracy in this respect and dependence must be placed upon the firm, but the stability of the standards made from these solutions is an important consideration. In testing bacteriological media add to 1 cc. of warm distilled water 4 cc. of melted agar to which has been added 1 cc. of the dye in one of the above bottles. In another bottle make another portion of diluted media without the dye. In another bottle put 20 cc. of distilled water. In comparing with the standards arrange the bottles on a shelf at the height of the eye with a backing of diffused daylight. Place the distilled water behind the bottle of diluted media containing dye and the bottle of diluted media without dye behind the dye standards. Make up the media (plain agar) as near pH 7.0 as possible. Results will be sufficiently accurate.

FRANK E. HALE.[4]

[4]Director of Laboratories, Department of Water Supply, Gas and Electricity, New York, N. Y.

## RECARBONIZATION OF SOFTENED WATER[5]

This paper should arouse the interest of water works men whose duty it is to operate water softening plants. Should Mr. Hill's paper do no more than focus attention upon certain operating conditions it will have served a useful purpose.

One of the most perplexing problems in water treatment of this kind is the effect of retarded chemical reactions, resulting in after-precipitation of lime and magnesium salts. Recarbonization may serve as an expedient, but, to the writer's mind, should not be considered entirely satisfactory. To evaluate properly this method, it is necessary to consider its ultimate effect from an economical and practical viewpoint. As has been shown by Mr. Hill, 90 per cent of the chemical reactions at the municipal plant at Columbus, Ohio takes place in the mixing chambers, whereas the remaining 10 per cent requires fifteen hours for removal of the hardening constituents, 7 per cent of which are precipitated in the filter beds and in the piping system. It is evident that, when conditions are favorable, precipitation of lime and magnesium is retarded and when these conditions are changed the softening action is accelerated greatly and the salts are deposited. As a result of retardation of reaction the lime and magnesium, (much of which are in a colloidal or semi-colloidal state) are re-dissolved by the $CO_2$ added for recarbonization and are passed through the softening system. This will relieve, in a large measure, the operators' difficulty, but puts the burden upon the ultimate consumer, especially when the water is used for steam making, in laundries and in other industrial processes. It may be argued that recarbonization results in only slight increases in the hardness of the water, but even slight increases of incrusting salts involve comparatively large losses to the industries using such water. Every grain per gallon of increased hardness represents a proportional financial loss in steam boiler operation and in soap and soda used in laundries. In addition to this fact there is a proportional reduced efficiency in zeolite softening plant operation and an increased operating charge in maintaining such systems. Similar operating difficulties will prevail in many other types of industrial water purification apparatuses.

[5]See Journal, March, 1924, page 393.

Water purification methods are changing rapidly and many hypotheses conceived a few years ago have been exploded when considered in the light of the present knowledge of physical chemistry. The writer is unwilling to concede that the problem of retarded action in a softening system and after-precipitation is an insurmountable one, nor does it appear unreasonable to assume that the formation of incrustation on sand grains may not be eliminated completely. The solution of this problem lies, the writer believes, not in recarbonization, but in a better understanding of the basic principles of coagulation and dispersion of particles. The statement "that large settling basins are not necessary for the proper chemical re-actions at least, as has always been supposed, and certainly they are not always effective in sedimenting the lime carbonate when it is in a colloidal state" is interesting. This statement may shock many advocates of large subsidence basins. Past experience of the writer has demonstrated the fact that large basins are unnecessary, not only as an adjunct to water softening systems, but also when used in connection with ordinary mechanical filtration. There has been in the past a great waste of funds in the construction of large subsidence basins, the use of which has been a detriment rather than an advantage to efficient plant control.

S. T. Powell.[6]

[6]Consulting Chemist, Baltimore, Md.

## SOCIETY AFFAIRS

### CALIFORNIA SECTION

The fourth annual convention of the California Section was held at the American Legion Hall, Fresno, California, as the guests of the Fresno City Water Company, October 25, 26 and 27, 1923.

One hundred and forty-three members and guests registered from all parts of the State.

The following papers were read:

Water System of Fresno City Water Corporation, by E. K. Barnum, Engineer of Fresno City Water Corporation.

Proper Arrangement of Plumbing for Buildings Higher than Can be Adequately Served Directly from Distributing System, by George Read, Superintendent, Meter & Service Department, Bureau of Water Works & Supply, Los Angeles. Read by George Pracy of Spring Valley Water Company.

Types of Pipe for Water Main Construction, by S. B. Morris, Chief Engineer, Pasadena Water Department.

Public Relations, by Al. C. Joy, Publicity Manager, San Joaquin Light & Power Corp.

Use of Balancing Reservoirs in Water Distributing Systems, by J. E. Phillips, Assistant Engineer, Bureau of Water Works and Supply, Los Angeles, California.

Effect of Distributing System Design upon Fire Insurance Rates, by Louis Stocklmeir, Engineer, Pacific Board of Fire Underwriters.

Softening of Public Water Supplies, by Gale S. Strout, Consulting Engineer, San Francisco. Read by E. A. Flanders, Associate.

Water Measuring Devices, by R. L. Daugherty, Professor of Mechanical Engineering and Hydraulics, California Institute of Technology, Pasadena.

Reasonable Water Sanitation Requirements, by Dr. Carl Wilson, Bacteriologist, Bureau of Water Works & Supply, Los Angeles, California.

European Experiences, by Chas. Gilman Hyde, Professor of Sanitary Engineering, University of California.

In addition to the above papers the following five minute talks were presented and discussed:

Legal Phase of Installation of Check Valves on Water Services, by C. B. Jackson, Superintendent, Fresno City Water Corporation.

Methods of Financing Water Main Extensions, by P. Diederich, Superintendent, Public Service Department, Glendale.

Water Service Installations Standards, by George A. Bragg, Maintenance Engineer, Pacific Gas and Electric Corporation, San Francisco.

Use of Detector Instruments for Water Works Purposes, by L. L. Farrell, East Bay Water Company, Oakland.

Advisability of Installing Sealed Services Ahead of New Paving, by A. P. Lovell, Superintendent of Water, San Diego.

Roofs for Distributing Reservoirs, by Chas. W. Given, Superintendent of Water Works, Monrovia.

On Friday noon the members were guests of the exhibitors at a luncheon given at the Fresno Country Club. On Thursday night and Friday night the Fresno City Water Company acted as hosts at dinners given to members and guests at the Fresno Hotel, and on Saturday everyone enjoyed an interesting trip to the Kerckhoff Dam and power house of the San Joaquin Light and Power Corporation with lunch at the power house as guests of the Corporation.

At a business meeting held at the Fresno Hotel Thursday evening, October 25, the following officers were elected for the coming year:

Chairman, Fred J. Klaus, Assistant Chief Engineer, East Bay Water Company, Oakland, California; Vice-Chairman, George W. Pracy, Superintendent, Fresno City Water Corporation; Secretary-Treasurer, S. B. Morris, Chief Engineer, Pasadena Water Department.

Additional members of Executive Committee elected are: C. B. Jackson, Superintendent, Fresno City Water Corporation; P. Diederich, Superintendent Public Service Department, Glendale, California.

## NORTH CAROLINA SECTION

The annual meeting of the North Carolina Section began Tuesday afternoon, November 13, at which time registration took place.

On Tuesday evening there was a dinner given by the Kiwanis and Rotary Clubs with Judge Guion as Toastmaster. The address of welcome was given by City Attorney Romulus A. Nunn; response by E. B. Bain of Raleigh, President of the North Carolina Section.

There was an address by Congressman Abernethy in which he said that North Carolina needs advertising. It is blessed with natural resources more than other places which have wider fame and prosperity. He also gave an account of his 17,000 mile trip around United States, Alaska, Canada, etc.

*Wednesday morning, November 14.* The minutes of the Gastonia meeting were read and adopted. The Secretary-Treasurer's report was adopted. Mr. Maffitt's resolution to extend to the Clubs a rising vote of thanks for the dinner and entertainment of the previous evening was unanimously carried. Mr. Kellogg and Mr. Maffitt were appointed as a canvassing committee to canvass election returns.

A letter was read from the Charlotte Chamber of Commerce inviting the Section to hold its next meeting there. Mr. Vest, Superintendent of the Charlotte Water Works, pointed out the opportunities offered by Charlotte and the Southern Power Company at next convention. Mr. Widenhouse invited the Section to meet at Albemarle next year. Telegrams from civic organizations at Albemarle had not been received so Mr. Boyles made a motion to defer the choice of convention city until Thursday morning. This was unanimously carried.

Reports of committees: Statistics Committee, J. C. Michie, Chairman, no report; By-Laws Committee, H. E. Miller, Chairman, no report; Canvassing Committee, Mr. Maffitt made the following report: For President, J. C. Michie; Vice-President, W. M. Piatt; Secretary-Treasurer, T. Saville.

Mr. Godfroy extended an invitation to the members of the convention to make use of the Elks Club rooms. A similar invitation came from the Country Club.

A request was read from the Secretary asking that copies of all papers delivered be submitted to the Secretary.

J. O. Craig gave a paper on Metering Services. In the discussion of this paper Mr. Maffitt said that he was constitutionally opposed to unmetered services; that half of each meter is owned by the city and the other half by property owner in Wilmington. In Wilmington the Board of Health requires water installations metered or vacation of premises. Mr. Bain said that the legality of compulsory payment for meters is to be tested in Raleigh. Mr. Logan of Waynesville said that some towns charge rent on meters.

Mr. Bain introduced Mr. Diven, Secretary of the American Water Works Association, who talked on the growth of membership. Mr.

Diven said that there seems to be a surety of the formation of a Southeastern Section.

M'Kean Maffitt of Wilmington gave a paper on Cross Connections Between Public and Private Water Supplies. Mr. Maffitt made a resolution to the effect that "There shall be no physical connection between the public water supply system and any private water supply system wherein it is possible to get contaminated water into the public water supply system." Mr. McConnell in discussing this paper said that one cross connection can undo all that the best purification plant has done; that it is illogical to exercise extreme vigilance in plant and let industrial or fire supply pollute the system. Mr. Norcom said that the cross connection was an insidious thing, unknown by consumers; if they knew they would rebel against it. Mr. Maffitt said that the New Hanover Board of Health recently prohibited cross connections. Mr. Diven said that a resolution similar to Mr. Maffitt's had been passed by the National Convention; that the matter could be handled by a Board of Health, by statute or force. It usually requires force. Careless tapping of polluted supply in New England mill, where there were two independent supplies, caused an epidemic. Mr. Miller said that the State Board of Health must have the power of public opinion, therefore, the resolution is of great assistance.

H. E. Miller then gave a paper on the Objective, Policy and Procedure of the State Board of Health in Relation to Water Supply.

At noon there was a barbecue at Grantham Farm with extemporaneous talks by various individuals.

On *Wednesday afternoon, November 14*, a meeting was called to order at 2:15. Mr. Godfroy gave a paper on the Water Supply at the New Bern Fire.

J. W. Kellogg of the State Board of Health presented a paper on Algae and their Relation to Water Supplies.

A paper on the Trouble at Albemarle with Tannic Acid Derived from Vegetation and Stumps was presented by Mr. Widenhouse.

A. O. True gave a paper on the Trouble at Proximity with Brownish Gelatinous Substance which Reduced Filter Runs to Three-fourths Hour. Mr. Sweeney of Wilmington stated there had been trouble with air bound filters. The intake was surrounded with logs. Every time the logs were moved, gelatinous material would enter suction lines and form on filter beds, clogging them. This looked like mother of vinegar, skimmed off material. The underdrainage system is

cleaned every three years. The masses of mucilaginous matter came from accumulations on logs at the saw mill.

S. Brockwell spoke on Fire Protection. This paper was discussed by Mr. Maffitt, who gave his experience with a know-all fire chief at Wilmington. A 12-inch main was needed for fire supply, the fire chief wanted a 6-inch main. They compromised on a 10-inch and an 8-inch. The first fire got away from him. There should be coöperation between water and fire departments.

The members of Section convened on Wednesday evening for a supper, where Mr. Diven spoke on the benefits from membership in the Association.

There was a stirring talk by Mr. Bain urging North Carolina to win the Membership Cup and give it back to the National Association in the spirit in which it was donated. Mr. Maffitt and Mr. Craig talked on the advantages of being a member of the A. W. W. A.

Col. Ludlow talked on the importance and responsibility of providing domestic water supply; the safety and health of urban population are in the hands of the superintendent of water works; every water works man should appreciate the opportunity of becoming a member of the A. W. W. A.

Mr. Godfroy urged rotating the convention each year from east to west. He said he desired the record of the largest one-year increase in membership.

Gilbert C. White made a motion to give Mr. Godfroy and the ladies of New Bern a rising vote of thanks for entertainment. This was unanimously carried.

Mr. Brockwell contributed fun, jokes and songs.

Following this Mr. Wright gave a paper on the Hendersonville Water Supply, illustrated with lantern slides.

There was a discussion by Gilbert C. White emphasizing the popular demand for an unfiltered gravity system. He said that municipalities are often willing to pay 20 per cent of the total cost for this.

The question of laying pipe up steep slopes was discussed by Mr. Maffitt. Mr. Wright answered this by saying he used double bells at each blown-off; pipe should be laid from valleys *up* slopes of hills.

Mr. Norcom gave a study of the efficiency of the improved water purification plant at Wilmington. Mr. Catlett discussed the improvement of water plants in the State. Mr. Craig discussed the reduction in cost from using coal at $5.50 a ton and electricity at

1.72 cents k.w. hr. Mr. P. B. Streander of the Roberts Fibre Company said that within the last two years North Carolina had done more than any other three states in the construction of filter plants.

Mr. C. C. Covert gave a paper on Stream Flow Records for Water Supply, illustrated with lantern slides.

Mr. W. E. Hall, District Engineer, United States Geological Survey, discussed the importance of stream flow records on small as well as large streams, and the importance of getting long records for future water supply studies. He said that it is just as important to get stream flow records for sewerage. Accurate sewage flow records by this method should be had to determine treatment plant required.

Mr. Gilbert C. White asked about cost of gaging stations. The following data were given by Messrs. Hall and Covert: cost of installation of automatic gaging stations averages about $400 to $500; cost of instrument $140; cost of maintenance and installation about $200 per year; cost of sender and recorder for long distance recording station $375 approximately. In his discussion Mr. Covert advocated good permanent installations.

Mr. Maffitt gave Charlotte's experience with investing $276,000 in pipe line in 1904, and the stream going dry in 1911. Mr. D. McWilliams said that the minimum discharge must be known; with different conditions in the state there is no definite run-off per acre. Mr. Hall said that in Asheville there had been an inadequate supply of water because of no gaging and no meters on the line. Mr. Williams had advocated both. The city was almost out of water because of no impounding. This could not be foreseen because of inadequate records. They were short of water in 1922. Mr. Maffitt, in discussing the matter, said that when stage at Fayetteville is 2 feet 4 inches salt water got to Wilmington; this could be foreseen if there were adequate gaging stations. Mr. Brockwell's discussion was to the effect that the subject is so large that it extends beyond municipalities, and is a problem of such scope as to demand statewide attention. He recommended that the Section go on record to memorialize the General Assembly to provide funds to make thorough and complete stream flow studies. Mr. Brockwell made a motion that committees be appointed to urge the General Assembly to provide sufficient funds to make a "thorough survey of the State." This motion was seconded by Mr. Gilbert C. White. Mr. Brockwell suggested that no amount of money is too much to provide these

data. He wants North Carolina to take an active part in this work. Mr. D. McWilliams discussed the advantage of including gaging stations as part of other improvements at water plants. Mr. Brockwell's motion was unanimously carried.

*Thursday morning, November 15.* Unfinished business was first taken up. Mr. Widenhouse withdrew the invitation to hold the next convention at Albemarle, and moved that Mr. Vest's invitation to have the next convention at Charlotte be accepted. Mr. Maffitt boosted Wilmington for 1925. Mr. W. E. Hall boosted Asheville for 1925, and Mr. D. McWilliams also boosted Asheville for 1925. Charlotte's invitation was accepted.

Mr. W. J. Alexander offered an amendment to the motion of the previous day, "that State Board of Health notify all parties having cross connections that the same be removed or disconnected from the city water supply within a reasonable length of time." Mr. Maffitt in his discussion said that the State Board of Health does not say "must"—Need more force behind local water works officials whose hands are tied. Mr. Hall suggested that the resolution would be backing for the State Board of Health and he seconded the amendment. The motion was unanimously carried. Mr. H. E. Miller said that it is necessary for the State Board of Health to be backed by public sentiment; if the matter goes to court this resolution will be the strongest evidence in favor. Mr. Boyles favored the appointment of a committee to work out a plan for furnishing water to fire supply to avoid cross connections and made a motion to appoint this committee.

Mr. E. G. McConnell of Charlotte gave a paper on the Accurate Control of an Old Filter Plant. Mr. Vest in discussing this paper said that $5000 a year was a conservative estimate of the saving made by trained operators. Mr. Diven said that there are laws in two states requiring the examination of filter plant operators.

Mr. Miller gave the report of the Resolution Committee. Mr. Miller made a motion for the adoption of this report. Mr. Maffitt seconded the motion and it was unanimously carried.

Mr. E. E. Peacock of the University of North Carolina gave a paper on Cost Accounting System for Water Works Systems of Large Towns and Small Cities. In his discussion of this paper Mr. Maffitt brought out the importance of a standardized accounting system. Mr. Norcom said it is necesary to have a standardized accounting system if we are able to compare operating costs of different purifi-

cation plants of the State. It is difficult for anyone to determine costs accurately in accounting systems used at present and to arrive at the depreciation.

Mr. H. F. Davis of Wallace and Tiernan Company gave a paper on the Use and Handling of Chlorinators.

At *noon Thursday* there was an oyster roast at the New Bern Power Plant.

Mr. S. G. Lantz of the Darling Valve and Manufacturing Company gave the first paper at the *Thursday afternoon meeting.*

Mr. True gave a paper on the Disposal of Wastes from Dyehouses and Textile Plants. Mr. True's paper was discussed by Mr. Maffitt.

*Question box:* Mr. Diven will send questionnaire regarding standardization of services. Mr. Miller spoke of the importance of Mr. Peacock's paper; also of Statistics Committee, its work and significance; should stimulate better methods of accounting and record keeping; requires coöperation of water works operators and superintendents.

The President appointed the following Committee on Stream Flow: S. Brockwell, Chairman; M'Kean Maffitt and D. McWilliams.

The Acting Secretary reported the registration for convention as being 130 and 26 new paid memberships. The convention adjourned *sine die.*

## NEW YORK SECTION

On January 17 the New York Section, through its Secretary, invited the Sanitary Division of the American Society of Civil Enginners to join with them in a luncheon meeting at the Hotel Pennsylvania. This invitation was accepted by them and an enthusiastic and enjoyable meeting ensued. This meeting was addressed by Mr. Geo. W. Fuller, on double filtration of water supplies in Europe.

In the absence of the President, Chas. R. Bettes, of the New York Section, Mr. D. W. French, one of the Board of Governors, presided and Mr. Kenneth Allen, Chairman of the Sanitary Division of the American Society of Civil Engineers spoke a few words for them.

# ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

**Key:** American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

**The 8 m.g.d. Sioux Falls Iron Removal Plant.** F. G. GORDON. Eng. News-Record, **91**: 882–3, 1923. Water supply is obtained from large shallow wells. It is pumped to aerators of weir-step type, settled, and filtered. 16 filter units, each with capacity of 500,000 g.p.d. when operating at rate of 125 m.g.d. per acre. Plant cost $11,125 per m.g. capacity. Raw water contains 4 to 5 p.p.m. Fe, which is reduced to 0.15 p.p.m.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Tile Drains Collect Water for Small City Supply.** R. E. KOON. Eng. News-Record, **91**: 854–5, 1923. Condon, Ore., with a population of 1300, is located 2900 feet above sea level with no available water supply at this elevation. 6 in. tile lines with open joints, placed 6 to 12 feet below stream bed, give filtered supply which is chlorinated before use. Supply is pumped 4 miles and elevated 723 feet to town.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Industrial Waste Pollution Conference a Success.** ANON. Eng. News-Record, **91**: 682–4, 1923. Conference held in Philadelphia, under joint auspices of Engineers' Club and local section of Amer. Soc. C. E., October 16, 1923. Topics discussed: federal and state control of pollution; stream pollution as affecting navigation; industrial wastes in relation to water supply; stream pollution at Philadelphia; and coal mine drainage contamination of water supplies.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Concrete Bottom for Mechanical Water Filters.** A. L. GAMMAGE. Eng. News-Record, **91**: 430–1, 1923. Filter bottom is all of concrete, including channels, raised half cylinders with horizontal under-slots to form jets, and 3 in. spheres placed in spaces between tops of the half cylinders. Slots are ½ inch horizontal, 20 inches apart lengthwise. Ratio of slot discharge varies from 0.3 to 0.5 per cent of filter area. With this ratio, filters have filtered and washed evenly, leaving a level sand bed even when sand was dirty. This type of bottom replaced metal strainer and air-wash system at East Walpole, Mass. —*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Deferrizing Additional Water Supply of Berlin, Germany.** GORDON M. FAIR. Eng. News-Record, **91**: 426–9, 1923. Supply taken from wells, 115 to 200 feet deep. Average daily yield from each well, 78,000 gallons. Water

contains 8 p.p.m. Fe, which is entirely removed by aeration followed by filtration through gravel beds and sand filters.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Local Laboratory Control of Water Supplies in California.** C. G. GILLESPIE. Eng. News-Record, **91**: 401, 1923. State Board of Health is advocating installation of laboratories to make simple bacteriological tests on water supplies. These tests give valuable data in case of litigation and damage suits; apprise officials and consumers daily of safety of supply; and stimulate interest of operator in character of water treated. A list of recommended equipment is given.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Pollution of Water Supplies by Coal Mine Drainage.** C. P. COLLINS. Eng. News-Record, **91**: 638–41, 1923. Oxidation of pyrites causes acid character of coal mine waters. About 1 pound CaO, per 1000 gallons waste water, is required to neutralize acid and precipitate Fe. This treatment is recommended, with two hours sedimentation. Collins suggests thorough study of mine drainage treatment by United States Bureau of Mines.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Pitometer Survey Discloses Underground Leaks.** G. H. FENKELL. Eng. News-Record, **91**: 432–3, 1923. Pitometer survey, from 1919 to 1922, resulted in eliminating underground leaks amounting to 9,557,000 gallons daily; 3,380,000 gallons daily, unmetered fixature leakage, and 9,600,000 gallons daily, metered fixature leakage, were also eliminated; representing total of 24 gallons per capita per day saved. Per capita consumption for 1922 was 184 gallons. Detroit supplies 954,000 people and is 98.5 per cent metered.—*Frank Bachmann.*

**Disinfecting the City Water Mains of Otsego, Michigan.** E. D. RICH. Eng. News-Record, **91**: 431–2, 1923. Population of Otsego in 1920 was 3168. The polluted Kalamazoo river has been used for water supply, but not for drinking, for eight years. Recently, a deep well supply was put in service. Water mains were disinfected by dosing the 130,000 gallon suction well with 9 p.p.m. Cl for twenty-four hours. Dead ends were flushed until free Cl was detected. After Cl treatment discontinued, flushing was kept up until Cl reactions negative.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Final Report on Franklin Furnace Typhoid Outbreak.** C. K. BLANCHARD. Eng. News-Record, **91**: 429, 1923. An open gate valve and a leaky check valve between industrial and town supply systems of the N. J. Zinc Co. was probable cause of 114 cases of typhoid and 8 deaths. The specific infection was traced to 2 cases of typhoid, dejecta from which probably reached the Walkill river. —*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Controller Regulates Water Flow through Pressure Filters.** C. C. BROWN. Eng. News-Record, **91**: 446, 1923. Automatic control of flow is accomplished by closing or opening of butterfly valve, by movement of rod attached to rubber diaphragm in middle of chamber, 2 parts of which are connected by pipes to trailing and leading sides of orifice in filter effluent pipeline.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Making Meter Maintenance Pay Big Dividends in Texas.** J. W. HOCKADAY. Eng. News-Record, **91**: 439, 1923. When meters were neglected at Cleburne, Tex. income fell off; but, with meter maintenance, revenue increased $1.75 for every dollar expended on maintenance, and operating expenses decreased $5. Cf. this JOURNAL, **10**: 823, 1143.—*Frank Bachmann.*

**Elimination of Cat-Tails from Reservoirs.** L. E. BISHOP AND C. R. KNOWLES. Eng. News-Record, **91**: 509, 1923. Cat-tails exist under swampy conditions. Lowering ground water level below creeping root stalks will kill the plants. Another method suggested is to pull plants out by hand destroying roots as far as possible. Use of creosote oil, applied at water's edge, is also effective.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Water-Works Dam Withstands Record Flood.** V. V. LONG. Eng. News-Record, **91**: 724–6, 1923. Oklahoma City dam passed almost 5 times designed capacity, though 250 feet of the corewall failed. On October 15, peak flow doubled June record flow in North Canadian River. While damage was great, there was no interruption of service. *Frank Bachmann.*

**Pennsylvania Sanitary Water Board: Powers, Duties, and Policies.** W. L. STEVENSON. Eng. News-Record, **91**: 684–5, 1923. Board consists of secretaries of health, forests, and waters, attorney general, commissioner of fisheries, and chairman of public service commission. Functions are: to administer laws of state prohibiting pollution of its waters; and to study, investigate, and report on, ways of eliminating and preventing stream pollution detrimental to public health, animals, fish, or aquatic life, or to recreational uses. Streams are divided into classes. Class A are pure streams into which no contaminating wastes are permitted. In class B, pollution is controlled. Sewage and industrial wastes may be discharged into class C streams provided no public nuisance or menace to health is created.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**How Shall We Gage Water-Supply Purity?** EDIT. Eng. News-Record, **91**: 624–5, 1923. Urges caution in methods employed by United States Public Health Service to control standard of purity of water supplies. In promoting public health in water supplies, Service may be retarding progress along other lines which may bring greater returns for same expenditures. Judging character of supply by standard based on bacterial examination alone, may force a city to expend large sums of money to comply with this arbitrary standard, with no evidence that lives will be saved, or sickness prevented, thereby. Much weight should be given to sanitary survey and to vital statistics of a community, in deciding whether or not its water supply is safe for use on interstate trains and steamers.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**Iron Removal and Softening Plant, Benton Harbor, Mich.** PEARSE, GREELEY AND HANSEN. Eng. News-Record, **91**: 378–9, 1923. Water is taken from deep wells and the St. Joseph River. Because of an Fe content of 2 p.p.m. and hardness of 250 p.p.m., CaO is added to reduce both constituents. Plant has

nominal capacity of 2 m.g.d.: consists of: mixing chambers; Dorr clarifier, with 1 hour detention; sedimentation basins, with 8 hours detention; sand filters; and storage reservoir. Clarifier removes bulk of precipitate continuously, thereby reducing the number of times sedimentation basins must be emptied and cleaned. Clarifier provides means for returning portion of settled sludge to raw water so as to promote rapid reaction and precipitation of CaO with $HCO_3^-$ in water. Expts. on aeration with 4¾ hours sedimentation indicated no effect on Fe removal. Sand filtration removed Fe; but accumulations of Fe and crenothrix growth in filter were objectionable. CaO treatment gave best results with filtration, reducing Fe from 2 p.p.m. in raw $H_2O$ to 0.1 p.p.m. in the filtered $H_2O$.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

**The Corrosion of Yeovil (England) Water Mains in Clay.** C. H. WEBB. Water and Water Eng., **25**: 294, 1907, June 20, 1923. On 8 inch main laid in 1872 there were 14 bursts in clay section in 1922. The part of line laid in sand was in good condition. Holes occurred in vicinity of bells, on lower part of the pipe, where it lay in wet clay. Decomposition of pipe took two forms: (1) Graphite softening in absence of scale; (2) Similar softening, beneath scale formation. In case (1), metal is pitted; in case (2), it may be cut out with a knife, though soft areas recover their hardness on exposure. Yellow and gray clays affected pipe more than boulder and blue clays. $CaSO_4$ is present in crystals and ground water is high in $SO_4$. It is suggested that variation in concentration of ground water may produce electrical effect. Coating of bells was evidently abraded in handling, which was probably not considered important fifty years ago. Recoating is advised.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**The Drinking Water of the Côte d'Amour (La Baule and Le Pouliguen).** "L. D." L'EAU, **16**: 8, 85, August 15, 1923. La Baule, resort town near St. Nazaire, France, aerates and filters iron-bearing dune water. Aeration is accomplished by cascades. Settled water is applied to non-submerged sand filters by revolving sprinklers. Loire river sand is used. Plant was built in 1912.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**On the Use of Metallic Pipes.** E. FIJALKOWSKI. L'EAU, **16**: 8, 89, August 15, 1923. Polemical against author of paper attacking use of cast iron pipe in gypsum-bearing earth, on strength of experiences in Tunis. F. opposes use of steel pipe in moist earth even when tarred and covered with jute. Experiences cited are chiefly Italian.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**The Regulation of Wash Houses (Lavoirs).** MARCHOUX. Rev. hyg., **45**: 8, 735, August, 1923. Dangers to the water supplies taken from streams below wash houses are detailed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**The Sydney Water Supply.** ANON. Water and Water Eng., **25**: 296, 296, August 20, 1923. Two reservoirs, on Cordeaux and on Avon, are under construction and will increase storage of Nepean water shed from 20,743 to 84,553 million Imp. gallons. Another reservoir at Lupton, on Nepean river, will

add 11,600 million Imp. gallons.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**The Effect of Free Chlorine on the Gudgeon.** ANON. L'Eau, **16**: 7, 81, July 15, 1923. Wastes from a sewer were observed apparently to kill trout. Inquiry on waste (rinse waters from dye works), showed 3.5 p.p.m. free Cl. No trout being available, experiments were tried with gudgeon, and it was found that these fish, of about 10 cm. length, died in about two and one-half hours in water containing this quantity of free Cl. It was shown that sodium bisulphite could be used to destroy free Cl. Court of Appeals at Nancy held that wastes could easily be rendered harmless and assessed small fine against directors of dye works.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**Experiments on the Contamination of "Petit Cidre" and the Transmission of Diseases of the Typhoid Type.** P. PAQUET. Rev. hyg., **45**: 8, 749, August, 1923. Recent epidemic traced to "petit cidre" (Rev. hyg., **45**: 165, 1923.) "Petit cidre" is prepared by covering with water residue from pressing apples, afterwards pressing mass a second time. Pond water is much preferred for this maceration as it is soft; minerals in well waters affect subsequent fermentation. Pond water may be polluted. Quick consumption seem to be necessary in order to transmit typhoid; as typhoid, para A, and B organisms have only ephemeral existence in fermented product. B. coli is more resistant.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**Estimation of Iodides in Mineral Waters Containing Sulphides.** J. DUBIEF. Ann. des falsifications, 172–3, 80–2, 1923, Water and Water Eng., **25**: 296, 304, August 20, 1923. When water containing sulphides, sulphites, and organic matter, is treated with $KMnO_4$, first in alkaline, then in acid soln., immediate oxidation takes place; Cl, Br, and I are liberated. I can be estd. by adding given amts., of $NaHCO_3$, $CS_2$, $H_2SO_4$; with $H_2O_2$ to destroy excess $KMnO_4$. Test lies in comparing color of unknown and samples containing known amounts of KI.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**Three Reports on Question of the Divining Rod.** ANON. Water en Gas, May 11, 1923; Water and Water Eng., **25**: 296, 305, August 20, 1923. Subject is taken very seriously in Germany. Difficult to get operators to appear before juries of observers.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**Estimation of Free Chlorine in Drinking Water.** W. OLSZEWSKI. Water and Water Eng., **25**: 296, 291, August 20, 1923. Iodide of starch is sensitive to 0.21 p.p.m. free Cl: sensitiveness may be increased to 0.1 p.p.m. by filling flask from the bottom and agitating with 2 grams KI and 5 cc. of fresh 1 per cent starch soln. Orthotolidine gives good results, but Mn and Fe interfere, giving bluish green color. Olszewski prefers Raschig's benzidine soln. in HCl, as used for $SO_4$ detns. Waters high in $SO_4$ give precipitate. Carbonates cause trouble. Determine alkalinity in usual way; add enough 0.5 N HCl to neutralize; and enough Raschig's soln. to give 0.016 to 0.02 grams benzidine per liter.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**Sterilization of Water with Liquid Chlorine and Deodorization by Aeration,** ANON. Técnica, 55–71, May 1923; Water and Water Eng., **25**: 296, 306, August 20, 1923. Apparatus used is made by Patterson in England, Wallace and Tiernan in United States, and "Triton" in Germany. Pressure gages are similar, but volumetric meters differ widely, esp. in United States and English types. Particulars and diagrams of process of combining use of chlorination with pressure aeration.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**Anaerobes from Water Samples.** P. D. MEADER AND E. A. BLISS. Amer. Jour. Hyg., **3**: 4, 394, July, 1923. Expts. were made with 76 tubes of lactose broth cultures which had yielded gas, but failed to confirm as B. coli. Tubes had been inoculated with raw and treated waters in State Board of Health Laboratory, in Maryland. Sixteen, or 21 per cent of tubes, contained anaerobes, but only two of anaerobes recovered fermented lactose with production of gas; from which it is concluded that number of anaerobes which give false presumptive tests for B. coli is not as great as generally supposed. Presence of anaerobes seemed to bear no relation to total bacterial count in water samples.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

**The Practical Application of the Oligodynamic Action of Copper Salts on Bacteria.** Arch. Hyg., **89**: 253–61, 1921. From Chem. Abst. **16**: 1968, June 20, 1922. Disinfectant action of copper foil, referred to as oligodynamic action of copper, was investigated. One hundred thousand bacteria were apparently killed in 24 hours by concentration of 1 p.p.m. copper chloride; but, on removal of copper with ammonium sulfide, bacteria were still viable. Disinfectant action was inhibited by organic matter in concentrations which occur in natural waters.—*R. E. Thompson.*

**Cataphoresis of Colloidal Carbon.** STEPHANIE GOLDBERG. Kolloid-Z., **30**: 230–4, 1922. From Chem. Abst., **16**: 2052, July 10, 1922. On addition of aluminum sulfate, velocity of migration to anode passed through a maximum of $33 \times 10^{-5}$ cm./sec./volt at N/500,000.—*R. E. Thompson.*

**Electroadsorption as a Purely Chemical Phenomenon.** WO. OSTWALD. Kolloid-Z., **30**: 254–60, 1922. From Chem. Abst. **16**: 2053, July 10, 1922. Development of adsorption formula on basis of law of mass action can yield practical results only when, in place of stoichiometric mass of adsorbent, there is substituted active mass, which consists of sum of chemically active surface layers.—*R. E. Thompson.*

**The Theory of the Migration Velocity of Particles in a Viscous Medium when acted on by an External Force.** H. F. MAYER. Jahrb. Radioakt. Electronik. **18**: 201–39, 1921. From Chem. Abst. **16**: 2053, July 10, 1922.—*R. E. Thompson.*

**Adhesion Forces in Solution. II. Studies on Adhesion Series.** N. SCHILOW, Z. physik. Chem., **100**: 425–62, 1922; cf. C. A. **14**: 1775. From Chem. Abst. **16**: 2055, July 10, 1922.—*R. E. Thompson.*

**Dissociation and Hydrolytic Equilibria in Solutions of Salts of Carbonic and Boric Acids.** H. MENZEL. Z. physik. Chem., **100**: 276–315, 1922. From Chem. Abst., **16**: 2056, July 10, 1922. Mean value obtained by colorimetric and electrometric methods for second dissociation constant ($K_2$) of carbonic acid at 18° was $6.2 \times 10^{-11}$. From this value, $1.03 \times 10^{-4}$ is obtained for second hydrolytic constant.—*R. E. Thompson.*

**The Slow Hydrolysis of Salts.** A. TIAN. J. chim. phys., **19**: 190–216, 1921. From Chem. Abst., **16**: 2058, July 10, 1922. Discussion and theory of hydrolytic equilibria which are slowly established.—*R. E. Thompson.*

**Chemical Reactions and Radii of Curvature.** R. LUCE. Compt. rend., **172**: 1287–8, 1921; cf. C. A. **15**: 2375. From Chem. Abst. **16**: 2058, July 10, 1922. Further experiments in support of view that chemical action of liquid on solid depends on shape of latter, being greatest where mean curvature is greatest. Thus influence of curvature is same in liquids and gases.—*R. E. Thompson.*

**The Molecular Scattering of Light in Water and the Color of the Sea.** C. V. RAMAN. Proc. Roy. Soc. (London), **101A**: 64–80, 1922; cf. C. A. **16**: 529. From Chem. Abst. **16**: 2076, July 10, 1922. Sufficiently deep layers of water exhibit, by molecular scattering, a deep blue color which is primarily due to refraction. Intensity of molecular scattering is approximately 160 times that of dust-free air.—*R. E. Thompson.*

**How Life and Performance of the Lead Storage Battery May be Extended by Proper Care.** M. F. PACKARD. Coal Age, **21**: 733–4, 1922. From Chem. Abst., **16**: 2082, July 10, 1922. Surface should be protected by acid-resisting paint, and corrosion of terminals retarded by use of grease. Specific gravity of electrolyte should be 1.27–1.28 at 21° with a correction of 0.001 for each 1.7° above or below this temperature.—*R. E. Thompson.*

**The Use of Colored Glass in Place of Liquids in Colorimetric Investigations.** KLAS SONDÉN. Arkiv. Kimi, Mineral., Geol., **8**: No. 7, 10 pp., 1921. From Chem. Abst. **16**: 2090, July, 10, 1922. Preparation and use of colored glass in H-ion concentration determinations, nesslerization, etc.—*R. E. Thompson.*

**A Starch Indicator Solution.** W. J. PAINTER. Analyst, **47**: 166–7, 1922. From Chem. Abst., **16**: 2090, July 10, 1922. Boil common household rice starch and equal weight of sodium carbonate with usual quantity of water. Cool and add concentrated hydrochloric acid until acid to litmus. Add a little zinc, allow to stand twenty-four hours, and filter the neutral solution. Will keep 8 months.—*R. E. Thompson.*

**Influence of Ethyl Alcohol on the Color Change of Phenolphthalein.** R. WEGSCHEIDER. Z. physik. Chem., **100**: 532–6, 1922. From Chem. Abst., **16**: 2090, July 10, 1922. At transition point in alcohol solution H-ion concentration is $9 \times 10^{-12}$ and the OH-ion concentration $2 \times 10^{-4}$.—*R. E. Thompson.*

**Xylenol Blue and its Proposed Use as a New and Improved Indicator in Chemical and Biochemical Work.** ABRAHAM COHEN. Biochem. J., **16**: 31–4, 1922. From Chem. Abst., **16**: 2090–1, July 10, 1922.—*R. E. Thompson.*

**Colorimetric Estimation of Phosphoric Acid.** ACH. GRÉGOIRE. Bull. soc. chim. Belg., **29**: 253–8, 1920. From Chem. Abst., **16**: 2093, July 10, 1923.—*R. E. Thompson.*

**The Determination of Free Acid in Aluminum Sulfate Solutions.** H. ZSCHOKKE AND L. HAUSELMANN. Chem.-Ztg., **46**: 302, 1922. From Chem. Abst., **16**: 2093, July 10, 1922. To 10 cc. alum solution add 10 cc. 10 per cent barium chloride, 5 cc. 10 per cent potassium ferrocyanide (not over 6 days old), and 60 cc. boiling water. While shaking, add warm 2 per cent gelatin solution (may be preserved with nitrobenzene) until precipitate is flocculent and settles well (about 1 to 1.5 cc.). Dilute to 100 cc., filter, and titrate 50 cc. of filtrate with $N/10$ sodium hydroxide, using methyl orange as indicator.—*R. E. Thompson.*

**The Application of the Indicator Method to the Examination of Stomach and Intestinal Juice.** L. MICHAELIS AND F. MUELLER. Deut. med. Wochensch., **48**: 252, 1922. From Chem. Abst., **16**: 2154, July 10 1922. Colorimetric method with nitro and dinitrophenols and crystal violet.—*R. E. Thompson.*

**The Analysis of Water.** F. TOUPLAIN. Chimie et industrie, **7**: 634–9, 1922. From Chem. Abst. **16**: 2189, July 10, 1922. Scheme of analysis recommended for identification of samples of unknown origin comprises determinations of conductivity, freezing point, refractive index, ionization, residue at 180°, sulfated residue, chlorine, bromine, iodine, arsenic, and sulfur (in its various forms). Portable apparatus for conductivity determinations is described.—*R. E. Thompson.*

**Substances Dissolved in Rain and Snow.** SHERMAN SHAFFER. Chem. News, **124**: 35–6, 1922. From Chem. Abst., **16**: 2190, July 10, 1922. Details of analyses of 45 samples collected at Mount Vernon, Iowa, given. No regular differences in amounts dissolved by rain and snow observed.—*R. E. Thompson.*

**Hypochlorous Acid and Chlorine, with Comparisons of Bleaching Action.** R. L. TAYLOR. Am. Dyestuff Rep., **10**: 329–30, 347–9, 1922. From Chem. Abst., **16**: 2200, July 10, 1922. Bleaching with chlorine may not be altogether due to decomposition of water, as chlorine may act directly on coloring matter.—*R. E. Thompson.*

**Cement and Its Painting.** ANON. Farben-Ztg., **27**: 1652–3, 1922. From Chem. Abst., **16**: 2207, July 10, 1922. New cement should be allowed to age before painting. Methods of treatment where this is impossible are given.—*R. E. Thompson.*

**Boiler Room Performance and Practice of the Colfax Station, Duquesne Light Co.** C. W. E. CLARKE. Mech. Eng., **44**: 295–300, 1922. From Chem. Abst., **16**: 2212, July 10, 1922. Fuel and fuel handling equipment, stokers and clinker grinders, ash handling and sampling, piping and feed water systems, and boiler plant of 7 B. and W. boilers described. Average efficiency for six months, 77.5 per cent.—*R. E. Thompson.*

**Bleaching with Hypochlorite.** RASSER. Chem. Tech. Ind., **19**: 457–9, May 10, 1921. Chimie et industrie, **7**: 764, 1922. From Chem. Abst., **16**: 2229, July 10, 1922. Sodium hypochlorite, particularly electrolytic, most important hypochlorite. Sterilization of linen was complete, even with resistant pathogenic organisms, in four hours with 2 per cent available chlorine. Cost compares favorably with bleaching powder.—*R. E. Thompson.*

**Standard Scouring Systems.** J. SCHOFIELD. J. Soc. Dyers and Colour., **37**: 298–301, 1922; cf. C. A. **15**: 760. From Chem. Abst., **16**: 2228, July 10, 1922. Water containing 6 to 7° hardness should be softened for scouring purposes. Surface water should be filtered.—*R. E. Thompson.*

**The Minimum Solubility of Aluminium Hydroxide in Water.** A. MASSINK. Chem. Weekblad, **19**: 66, 1922. From Chem. Abst., **16**: 2246, July 20, 1922. To explain differences in results of Am. investigators (A. Wolman and F. Hannan and also Blum) and those of Ada Prins and of Van de Sande Bakhuyzen, it is pointed out that former did not use chemically pure water, while latter took this into consideration.—*R. E. Thompson.*

**Hour Radioactivity of Mineral Waters. Carbonic-Sulfur-Boric Waters of the Saturnia Hot Springs.** R. NASINI AND C. PORLEZZA. Giorn. chim. ind. applicata, **3**: 543–5, 1921. From Chem. Abst., **16**: 2256, July 20, 1922.—*R. E. Thompson.*

**Report of Water-Softening and Purification Works for the Year, 1921.** CHAS. P. HOOVER. City Bull. (Columbus, Ohio) **7**: 16, 12–21, 1922; cf. C. A. **15**: 3352. From Chem. Abst., **16**: 2377, July 20, 1922. 7936 million gallons softened (lime soda) to average hardness of 100 p.p.m. Average reduction in bacteria from 2450 to 24 per cubic centimeter, 10 deaths from typhoid occurred during year.—*R. E. Thompson.*

**The Purification of Turbid Water for Use in Boilers.** ANON. Wärme u. Kälte Technik. **24**: 81, 1922. From Chem. Abst., **16**: 2377. Brief description of purification by precipitation, settling and filtration.—*R. E. Thompson.*

**Whitewashes and Aqueous Lime Paints.** G. L. FINK. J. Ind. Eng. Chem., **14**: 503–11, 1922. From Chem. Abst., **16**: 2418, July 20, 1922. Those containing siccatives are much more permanent. Casein and linseed oil are best binders. Addition of hardening agents, such as formaldehyde, to render film less soluble, considerably improve durability. Sodium chloride and alum added to whitewashes containing no definite siccative improve workability and permanence.—*R. E. Thompson.*

**Water Softening for Industrial and other Purposes.** J. P. O'Callaghan. J. Soc. Dyers and Colourists, 38: 81–4, 1922. From Chem. Abst., 16: 2189, July 10, 1922. Comparison of Lassen-Hjort and permutit methods.—*R. E. Thompson.*

**Condition Equation of Water.** O. Tumlirz. Sitz. Akad. Wiss., Wien. Abt. IIa, 130: 93–133, 1921. From Chem. Abst., 16: 2444, August 10, 1922. Equation of state for water developed and verified by experiment. Occurrence of maximum density depends solely upon manner in which cohesion pressure depends on temperature.—*R. E. Thompson.*

**Demonstration of the Use of a Universal Indicator.** F. H. Carr. Analyst 47: 196–7, 1922. From Chem. Abst., 16: 2458, August 10, 1922. Range and color changes of universal indicator of Moir, modified by Cocking and Chappel, for water testing. Changes correspond to spectrum. pH range, 3 to 11.—*R. E. Thompson.*

**Purification of Water and De-incrustation of Boilers.** F. H. Lecomte. E. P. 200, 466, 1.8.22. Conv., 5.7.22. Jour. Soc. Chem. Ind., 42: 46, 1094A, November 16, 1923. Boiler compounds are prepared by mixing with water a small proportion of ultramarine, alum, and naphthalene, and a large proportion of sodium carbonate. A suitable compound is prepared by mixing 100 liters of water at 17°C. with 2 grams of ultramarine blue until a uniform coloring is obtained; 5 grams of naphthalene and about 12 grams of alum are then added whilst constantly stirring, followed by the gradual addition of 160 kilograms of sodium carbonate. The paste obtained is allowed to rest for about 7 mins. and then poured into moulds, or upon plates, to cool and solidify. One kilogram of this composition is used with 20 cb.m. of water to remove scale, and one-third the quantity to prevent its formation. Material may be used to purify water for laundry purposes and for treatment of sea water (W. T. L.).—*A. M. Buswell.*

**Manufacture of Base-exchanging Compounds.** J. Crosfield and Sons, Ltd., T. P. Hilditch, and H. J. Wheaton. E. P. 203, 158, 14.8.22 and 1.5.23. 1094A. Jour. Soc. Chem. Ind., 42: 46, 1094A, November 16, 1923. Homogeneous gels, which when washed and dried may be used as base-exchanging compounds (cf. E. P. 177, 746; J., 1922, 372 A.), are obtained by mixing solutions of sodium silicate in which ratio of silica to alkali is not less than 3.3 to 1, with solutions of one or more of the following—sodium chloride, sodium chlorate, sodium sulphate, sodium nitrate, disodium phosphate. With a silicate having a ratio of silica to soda between 3.3:1 and 3.7:1 a concentrated solution of silicate is required (sp. gr. 1.2–1.4) and also a concentrated solution (50 per cent) of the other sodium salt or salts employed. With silicates of ratios 3.7 of silica and upwards, to 1 of soda, less concentrated solutions give good results (W. T. L.).—*A. M. Buswell.*

**Process of Regenerating Base-exchanging Compounds after Use.** J. Crosfield and Sons, Ltd., T. P. Hilditch, and H. J. Wheaton. E. P. 203, 497,

14.8.22. Jour. Soc. Chem. Ind., **42**: 46, 1094A, November 16, 1923. In the regeneration of base-exchanging compounds in accordance with E. P. 4188 of 1913 (J., 1914, 216), the greater part of the lime and magnesia is removed by first portions of the brine. Economy is effected by preliminary treatment with solution, or solutions, partially spent in previous regenerations. For final treatment, fresh unused brine is employed, which, after use, is reserved for subsequent operations (W. T. L.).—*A. M. Buswell.*

**Process for Purifying Water.** P. HERRERO. E. P. 203, 886, 1.9.22. Jour. Soc. Chem. Ind., **42**: 46, 1094A, November 16, 1923. Process for purification of water by means of barium bicarbonate in solution and calcium hydroxide (cf. E. P. 20, 591 of 1908; J., 1909, 324). Water, kept in continual agitation by means of stream of air mixed with purified carbon dioxide, when saturated with carbon dioxide, is treated with finely ground barium carbonate, in small quantities at a time, until sulphates present are completely precipitated. At this stage, passage of carbon dioxide is discontinued, and milk of lime added, to remove the bicarbonates of calcium, magnesium, etc., formed, together with the small amount of barium bicarbonate remaining in solution. When reaction is complete, agitation is stopped and mixture allowed to settle (W. T. L.). —*A. M. Buswell.*

**Occurrence of Iodine in Nature.** T. VON FELLENBERG. Mitt Lebensmittelunter. Hyg., **14**: 161–240. Chem. Zentr., 94, III, 986, 1923. Jour. Soc. Chem. Ind., **42**: 45, 1068A, November 9, 1923. Gives simple qualitative test for iodine, sensitive to 0.4 mg. per kg. With this test, author determined the iodine in air, soil, fog, surface and ground waters, and a large number of fruits, vegetables, and other food materials. He confirms Chatin's conclusion, that cretinism can be brought about by lack of iodine and can be prevented by administration of sufficient iodine. (Cf. J., 1923, 945A.)—*A. M. Buswell.*

**Chemistry of Surface Waters and Filtration Processes.** HURDELBRINK. Gas. u. Wasserfach, **66**: 570–72, 1923. Jour. Soc. Chem. Ind., **42**: 50, 1195A, December 14, 1923. Brown incrustation in pipes of water supply of town of Königsberg from time to time becomes detached, and causes discoloration of the water. Examination showed such low proportion of organic carbon that crust could not have been formed by action of humic acid on iron. It was essentially ferric oxide and also contained 1.8 per cent elementary sulfur. Its periodical formation and removal was therefore probably due to variations in amounts of carbon dioxide and oxygen in solution, disappearance of latter also favouring growth of sulfur bacteria. Regular tests were made of fluctuations of content of oxygen, carbon dioxide, iron, and organic matter, at different periods of the year, before and after filtration. It was shown that reduction of oxygen content and of content of oxidisable organic matter, and increase of carbon dioxide content, are permanent effects of filtration. Very marked effect was shown by periods of frost in winter during which filters were frozen over and aeration prevented. Other seasonal changes were ascribed to development of bacterial life in the water in proportion as temperature favoured this (C. I.).—*A. M. Buswell.*

**Rapid Method for the Purification of Drinking Water.** C. A. Grau. Anal. Asoc. Quim. Argentina, **11**: 82–85, 1923. Jour. Soc. Chem. Ind., **42**: 50, 1195A, December 14, 1923. Following solutions are recommended for rendering doubtful waters potable: Solution A; iodine, 8 grams; potassium iodide, 2 grams; glycerin 2 cc.; ethyl alcohol, 90 cc. Solution B; sodium thiosulfate 15 grams; glycerin, 5 cc.; water, 45 cc.; ethyl alcohol, 40 cc. Five drops of Solution A are added to each litre of water. If water is not thereby colored slightly yellow, a few more drops are added. After agitating occasionally for 20 minutes, an equal volume of Solution B is added. Products of reaction between Solutions A and B, 0.03 grams of sodium tetrathionate and 0.008 grams of sodium iodide per litre, are considered to be harmless (G. W. R.).—*A. M. Buswell.*

**Apparatus for the Separation of Gases from Liquids.** H. Wade. From W. S. Elliott. E. P. 204, 363, 29.5.22. Jour. Soc. Chem. Ind., **42**: 50, 1196A, December 14, 1923. An apparatus for removing gases from liquids such as boiler-feed water, which depends for its effects on sudden ebullition of preheated and finely divided water in vacuum, is constructed as far as possible with all apparatus in or on one vessel, which forms the vacuum chamber, so as to avoid friction and heat losses in pipework.—*A. M. Buswell.*

**Ammoniacal Liquor for Softening Water.** Chevalet. Soc. Tech. de l'Ind. du Gaz en France. Gas J., **163**: 735, 1923. Jour. Soc. Chem. Ind., **42**: 42, 996A, October 19, 1923. Boiler-feed water is preheated and softened in apparatus comprising 5 superposed trays, each 40 cm. in diam., capacity of plant being 500 liters per hour. Ammoniacal liquor is added at rate of 50 liters per twenty-four hours, and water is agitated with steam as it flows over each tray. When temperature of 60°C. attained, the ammonium carbonates primarily formed are decomposed, the ammonia passing upwards with steam, and softening more water. Water thus treated passes into settling tank of 4 cub. m. capacity (H. Hg.).—*A. M. Buswell.*

**Determination of the Content of Active Carbon Dioxide in Drinking Waters.** P. Lehmann and A. Reuss. Z. Unters. Nahr. Genussm., **45**: 227–236, 1923. Jour. Soc. Chem. Ind., **42**: 42, 996A, October 19, 1923. A consideration of the work of Schloesing (Comptes rend., **74**: 1552, **75**: 70, 1872) and application of law of mass action lead to deduction of following formula for calculating combined carbon dioxide, $c$, in drinking water from total carbon dioxide, $t$, both expressed in mg. per litre:—

$$c = (\sqrt[3]{t + t^2 + 5823} + \sqrt[3]{t - t^2 + 5823})\ 27$$

If $t$ exceeds 200, a correction is necessary on account of carbonate not being completely dissociated at higher concentrations. This correction factor is deduced to be $2772.9/(2886-c)$. Table is given of sums of concentrations of combined and active carbon dioxide corresponding to experimentally determined total carbon dioxide concentrations, calculated by means of above formula, correction factor being applied where necessary. Details are given of methods of determining combined and free carbon dioxide by titration with hydrochloric acid using methyl orange as indicator, and with sodium

carbonate using phenolphthalein as indicator, respectively. Active carbon dioxide in water containing calcium sulfate must be determined directly by experiments on powdered marble, according to Van Heyer's method (Gesundheitsing. **35**: 675, 1912; see also Kolthoff, J. S.C.I., 1921, 95A). (H. C. R.).—*A. M. Buswell.*

**Detection of Nitrites (in Water) by Rodillon's Test.** H. HELLER. Chem. Zeit., **47**: 701, 1923. Jour. Soc. Chem. Ind., **42**: 42, 996 A, October 19, 1923. Leffmann's failure (J. S. C. I., 1923, 326A.) to obtain consistent results by use of Rodillon's test (J. S. C. I., 1923, 27A) is due to heating acid used in dissolving the resorcinol. Good results are obtained by shaking 0.4 gram resorcinol with 5 cc. cold concentrated sulphuric acid, and introducing 1 cc. of this solution below 5 cc. of water to be tested, contained in test-tube. A green to violet or blue color at interface denotes presence of nitrites. (Cf. J. C. S., October.) (A. R. P.).—*A. M. Buswell.*

**Apparatus for Removing Gases from Boiler Feed Water and Other Liquids.** THE GRISCOM-RUSSELL CO., Assees. of R. C. Jones. E. P. 196, 238, 5.7.22. Conv., 14.4.22. Jour. Soc. Chem. Ind., **42**: 42, 996A, October, 1923. Feed water is sprayed into chamber under reduced pressure in which it is heated by tubular heat exchanger. In order to loosen, or crack, scale deposited on tubes, these are so formed that they are flexed or deformed upon subjection to changes of temperature. For this purpose, each tube may be slightly bowed out of a straight line, or its cross-section may be deformed out of a true circle. In latter case, flattened sides of adjacent tubes, or of adjacent turns of spiral, or helical, tube, are preferably disposed adjacent to each other (H.H.).—*A. M. Buswell.*

**Water Supply and Purification.** GEORGE W. FULLER. Am. Pub. H. Assn., 1923. Can. Engr., **45**: 487-8, 1923. General review of water supply, water supply projects, excess Cl, effect of mine drainage, corrosion of service pipes, and modification of U. S. P. H. S. standard.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

**Method and Cost of Constructing Malone Diversion Dam.** Reclamation Record, Sept. 1923. Eng. Contrg., **50**: 1048–9, 1923. Construction of earth dam, with concrete spillway, and canal headwork, is described in detail with cost data.—*Langdon Pearse.*

**Water Works Accounting System of Charleston, S. C.** E. E. EVANS. Tri State Water & Light Assn., 1923. Eng. Contrg., **50**: 1050–1, 1923. Details are given of meter system, and books; with recommendations for sinking fund, depreciation charges, and proper accounting on extensions.—*Langdon Pearse.*

**Repairing Coagulation Basins with Cement Gun.** A. S. HOLWAY. Eng. Contrg., **50**: 1004–6, 1923. To repair concrete disintegrated by frost, cement gun was used with forms having one side and top. Work was done on cost plus basis, costing $42.90 per cubic yard in place.—*Langdon Pearse.*

**Operation Records for Small Water Works.** E. L. WATERMAN. Am. W. W. Assn. (Iowa), 1923. Eng. Contrg., **50**: 1007–8, 1923. Better records are urged for small works.—*Langdon Pearse.*

**Shrink-fitting Heavy Shaft Assembly.** C. V. FOULDS. Eng. Contrg., **50**: 1009–10, 1923. To assemble generators on shaft, spider hubs were heated by steam, then placed and cooled.—*Langdon Pearse.*

**Problems of the Private Water Company.** W. W. COLLEGE. Eng. Contrg., **50**: 1038–40, 1923. General discussion of rate making and accounting, with reference to Pennsylvania conditions.—*Langdon Pearse.*

**Supervision of Water Treatment Plants in Michigan.** E. D. RICH. Am. W. W. Assn. (Iowa), 1923. Eng. Contrg., **50**: 1041–2, 1923. Details methods of supervision used. Local laboratories are encouraged.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

**Roof Truss Derrick Erects Standpipe.** Eng. Contrg., **50**: 1042–3, 1923. In erecting standpipe, 60 feet in diameter by 100 feet high, the roof trusses were used to form derrick.—*Langdon Pearse.*

**Financing Water Main Extension by City Owned Plants.** H. F. BLOMQUIST. Am. W. W. Assn. (Iowa), 1923. Eng. Contrg., **50**: 1045–6, 1923. Methods of financing by special assessments, or contract, are described, with reference to Iowa conditions.—*Langdon Pearse.*

**The New Pumping Unit of Trenton, N. J., Water Works.** Eng. Contrg., **50**: 1047–8, 1923. Roots pump, driven by 850 H. P. Uniflow engine; delivery, 20 m.g.d., against 155 feet head.—*Langdon Pearse.*

**Water Works Addition in New England.** ALLEN HAZEN. N. E. W. W. Assn., 1923. Eng. Contrg., **50**: 1023–7, 1923. Describes in detail new work underway at New Britain (wells), Springfield (enlarging filter), Providence (new filters), Poughkeepsie and Albany (pre-treatment).—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

**Adopting Proper Schedule of Water Rates.** W. W. RICH. Eng. Contrg., **50**: 1032–4. Recommends budget system; eliminating leaks; metering all services; making rates according to cost, based upon service charge plus meter charge.—*Langdon Pearse.*

**"Our Water Supplies."** EDWIN THOMPSON. Chem. Ind., **42**: 48, 1152 R, 30 November, 1923. A brief survey of water supply and purification problems in Great Britain with historical notes concerning the Glasgow, Manchester, London, and Liverpool supplies.—*A. M. Buswell.*

**New Suggestion for Earth Dam.** F. A. NOETZLI. Am. Soc. C. E., Can. Engr., **45**: 555, 1923. Urges consideration of use of water tight diaphragm,

built up of two layers of granite, on slope of 1½:1, with asphalt between.—*Langdon Pearse.*

**Blind Slough Dam at Stave Lake, B. C.** A. F. TREDCROFT. Can. Engr., **45**: 541–4, 1923. Describes concrete dam 640 feet long, equipped with 10 stop log bays, each 22 feet long, and 4 Taintor Gates, each 19 feet ½ inch wide. Foundations are on granite. Methods of construction and plant are described. —*Langdon Pearse.*

**Concrete Underdrains at Worcester.** H. P. EDDY. Pub. Works, **54**: 379–80, 1923. In the sand beds handling sewage containing spent pickling liquids from wire mills, etc., concrete underdrains have disentegrated; possibly because of (1) peat underlying the beds, (2) acid in the sewage, (3) putrefactive condition in overloaded filters.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

**Self Purification of Rivers.** W. H. FROST, Am. Pub. Health Assn., 1923, Pub. Works, **54**: 386, 1923.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

**Derrick as Dragline.** F. C. SELLNON. Pub. Works, **54**: 387, 1923. In building the Wanaque dam, a stiff leg derrick is used as dragline, and also as cableway.—*Langdon Pearse.*

**Pollution of Kansas River.** Kansas State Board of Health, Pub. Works, **54**: 399, 1923. Self-purification leaves river in fair condition above Topeka. Below Topeka, conditions vary.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

**Water Purification Statistics.** Pub. Works, **54**: 399–401, 1923. Data are tabulated from 70 cities. Ninety-three per cent use Cl; 56 per cent filter.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

**Memphis New Waterworks.** F. G. CUNNINGHAM. Am. Soc. Mun. Improvements, 1923. Pub. Works, **54**: 371–4, 1923. Will serve about 165,000 population, now using 13 mil. gal. per twenty-four hours. New system of wells and new pumping plant replace the old. Aeration and filtration reduce high $CO_2$ (90 to 130 p.p.m.) and Fe (0.2 to 6.0 p.p.m.). Average daily supply of 18 mil. gal. is provided, at cost of $2,800,000. Air lifts will raise water into a receiving basin. Special precautions are taken for sightliness, and for care in making maintenance repairs.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

**The Need of Covering Open Service Reservoirs.** GEORGE C. BUNKER AND AUGUST C. NOLTE. Amer. City, **30**: 15, 1924. (Abstract from paper before N. E. Water Works Assn.) Sound arguments are presented for the covered reservoir. Advantages of making cover part of original installation are pointed out.—*W. Donaldson.*

**City of 10,000 Builds $50,000 Water System.** CHARLES MARTEL NILES. Amer. City, **30**: 21–23, 1924. Ilion, N. Y., is completing new gravity supply works. An earth fill, concrete-core-wall dam, 726 feet long and 80 feet high.

will provide 150 mg. storage, sufficient for five months supply. Creek supplying reservoir is fed from springs. Impounded water is piped to service reservoir near village where it is aerated through 70 spray nozzles; then passed through sand filter (type not stated) into covered clear basin which supplies distribution system. Chlorination is provided for emergency use. Watershed is being systematically reforested.— *W. Donaldson.*

**How Privately Owned Water-Meters May Be Acquired.** ANON. Amer. City, **30**: 41–42, 1924. Methods outlined and form of contract given.—*W. Donaldson.*

**Data on Water Furnished Schools.** ANON. Amer. City, **30**: 45, 1924. Tabulation of 21 Kansas municipalities show that a charge is customary for water furnished schools; that the charge is not less than made against other consumers; and that no difference in rate is made between board of education office and school buildings.—*W. Donaldson.*

**Protection of Wells Against Contamination by Cemeteries.** M. LE COUPPEY DE LA FORREST. Rev. D'Hyg., **45**: 8, 741, August, 1923. Author recommends, in place of requirements regarding distance intervening between dwellings and cemeteries, the lapse of time occurring before the ground of old cemeteries is again used for inhumations, and similar rules, the matter should be placed in hands of a competent geologist who should prescribe regulations for each locality, depending on character of soil, drainage, etc.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

**Influence on Fish and Other Forms of Stream Life of Washings from Bituminous Roads.** Standing Committee on Rivers Pollution (1921). Ministry of Agriculture and Fisheries. Report No. 40. In laboratory test young perch and roach showed no ill effects after three hours with extract from pulverized bituminous road material. In practical test, two-year-old brown trout were unharmed after 19 weeks in pond receiving actual drainage from bituminous road.—*A. W. Blohm.*

**Influence of Hydrochloric Acid as a Typical Acid and Sodium Hydroxide (Caustic Soda) as a Typical Alkali on Fish Life.** C. H. ROBERTS AND E. C. JEE. Standing Committee on Rivers Pollution (1921). Ministry of Agriculture and Fisheries. Report No. 36. Time until "Loss of Equilibrium" (basis for expressing endurance of fish) in acid of strength 1:5000, was nine minutes for perch and seven minutes for roach. With 1:10000 acid, period was thirteen minutes for perch and sixteen minutes for roach. With 1:5000 sodium hydroxide, the period was thirty-one minutes for perch and thirty minutes for roach. In 1:10,000 sodium hydroxide both endured forty minutes. Conclusion is that comparatively small concentrations of free acid or alkali are harmful to fish life.—*A. W. Blohm.*

**The Inception and Development of the Idea of Free Public Baths.** JEANIE WENTWORTH WELLS. Jour. Am. Assoc. for Promot. Hyg. and Pub. Baths, **5**:

14, 1923. Development from ceremonial bath of ancients to modern public bathing facilities.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

**Swimming Pool Sanitation.** M. Z. Bair. South. Med. Jour., **16**: 10, 764, October, 1923. Sanitation and safety important features in design of pool. Filtration, disinfection, care of suits and towels discussed.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

**Technique of Physiological Experiments as Carried out at the Fisheries Experimental Station of the Ministry of Agriculture and Fisheries at Alresford, Hants.** C. H. Roberts and E. C. Jee. Report No. 39, May, 1923. It is assumed, from experiments, that if yearling perch or trout suffer no harm during one to three hours treatment in given effluent, such effluent is in all probability not directly harmful to stream life. In an experiment, time and nature of adverse symptom is noted. Symptoms may be: rapid or unusual mode of swimming; distension of gill covers; gulping of jaws; quivering of body; loss of equilibrium.—*A. W. Blohm.*

**Influence of Common Salt on Fresh Water Fish.** C. H. Roberts. Ministry of Agriculture and Fisheries. Report No. 38, February, 1923. Small perch and roach withstood three-hour exposure to brine containing 575 parts combined chlorine per 100,000, about $\frac{1}{3}$ strength of sea-water. Equilibrium was lost in ten minutes on raising strength to 860 parts. Valuable report applicable to places where drainage (saline in nature) is discharged into streams or lakes, killing or driving out fish life.—*A. W. Blohm.*

**Some Observations on Aural Conditions Resulting from Pool and Sea Bathing.** H. Marshall Taylor. South. Med. Jour., **16**: 2, 134, February, 1923. Author records epidemic of acute external ear, middle ear, mastoid, and sinus infections among users of pool at Jacksonville, Florida, in 1917. Proper methods of operation and preventive sanitary precautions caused immediate cessation of epidemic. Lowering of body temperature and consequent lowering of resistance increasing susceptibility to pathogenic organism, is discussed.—*A. W. Blohm.*

**The Causes and Prevention of Otologic Conditions Following Swimming and Diving.** H. Marshall Taylor. Jour. Am. Med. Assoc., **81**: 5, 349, August 4, 1923. Reduction of temperature, or irritating chemicals, by stopping wave like motion of ciliated epithelium lining of nose, etc., and washing away of bactericidal nasal mucus may increase susceptibility to infection. Destructive action of water by osmosis may cause edema and acidosis of cells and eventually cell death. Author suggests plugging of nostrils and ears when bathing, and limitation of bathing period, in addition to present precautions.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

**The Mechanical or Rapid Filter—Improved False Bottom Design.** Indian and Eastern Engineer, **42**: 4, 145, October, 1923. Advantages of Wheeler Filter bottom pointed out to be: (1) Minimum of metal used; (2) metal parts

of simple construction; (3) complete distribution of wash water and high velocity; (4) maintenance of underdrain system in undisturbed condition; (5) wash water delivered at 15 gallons per square foot of filter at comparatively low head on wash water.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

**The Effect of Industrial Waste on Water Supply.** Jour. Am. Med. Assoc., **81:** 14, 121, October 6, 1923. Certain wastes in water result in tastes, sometimes medicinal and disagreeable, when water is chlorinated. Chlorophenol tastes were obtained when phenol was present 1 part in 750,000,000. Coke wastes should be kept out of the supply.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

**Double Filtration of Water as Practised in Europe.** Fire and Water, **75:** 4, 163, January 23, 1924. Water purification in European cities, especially the practice of double filtration in some cities taking supplies from highly polluted streams, was treated by George W. Fuller, C.E., at the joint meeting of New York Section, A. W. W. A., and Sanitary Section, A. S. C. E., held in New York, January 17.—*A. W. Blohm.*

**Report on Investigation of the Pollution of Streams.** N. Y. State Conservation Commission, 1923, pp. 50. Second in importance to sanitary sewage is waste from milk plants, which constitute two-thirds of the 3000 manufacturing plants listed as possible contributors to stream pollution in New York State. Use of streams in disposal of waste is important and legitimate and should be permitted and encouraged up to point of interference with use of greater value to community. Certain streams should be adjudged unfit for water supply and their use for such purpose prohibited, while streams properly used as source of supply should be guarded against pollution which would overload purification plants. Dilution is the controlling factor in all classes of wastes. Standards should be expressed in clear and definite terms, readily understandable, and demonstrable by definite tests. Cycle of formation and decomposition of organic matter is outlined, and aërobic and anaërobic decomposition and function of dissolved oxygen in oxidizing and stabilizing organic matter in water are discussed. Tests employed for determining quality of water are listed and their interpretation discussed, particular attention being given to the B. coli test and Wells's interpretation of same. Review of former work on living indicators of stream pollution and on oyster purification, and bibliography of ten references are included. Establishment of a Conservancy Commission, for regulation and control of uses of streams as affecting quality of water, is recommended.—*R. E. Thompson.*

**Lateral Earth Pressure: The Accurate Experimental Determination of the Lateral Earth Pressure, Together with a Resumé of Previous Experiments.** Jacob Feld. Proc. Amer. Soc. Civ. Engs., **49:** 4, 603–60, April, 1923. Tests on a model wall, 6 feet high and 5 feet wide. Tests with sand indicate reliability of Poncelet theory of maximum wedge causing oblique pressure. Settling and variation in temperature cause remarkable changes in lateral

pressure. Platform scales, adjusted to a movement of 0.004 inch, were used. A resumé of previous experiments is given.—*John R. Baylis.*

**Theoretical Frequency Curves.** H. ALDEN FOSTER. Proc. Amer. Soc. Civ. Engs., 49: 5, 825–55, May, 1923. Contains numerous mathematical formulas, and suggests use of frequency curves for computing stream run-off.—*John R. Baylis.*

**The Disintegration of Cement in Sea Water.** WILLIAM G. ATWOOD AND A. A. JOHNSON. Proc. Amer. Soc. Civ. Engs., 49: 6, 1039–64, August, 1923. Brief history of the study of cement for use in sea water. Attempt to make use of a standard cement for all purposes has probably been the cause of many failures. All experiments for the past 100 years agree that primary cause for disintegration in sulfate-bearing waters is the attack on free lime by sulfates. Disintegration may be prevented by adding to cement a properly constituted silicious material which will form a cementing material insoluble in sulfate-bearing waters. High alumina cement attains the same result. Authors conclude that in view of the great volume of previous research work, the study being made at University of Saskatchewan, and the general agreement in results obtained, it is unnecessary to make further tests to determine causes of failure of concrete in sulfate-bearing waters.—*John R. Baylis.*

**Some Notes on British Water Works Pumping Engines.** F. JOHNSTONE-TAYLOR. Fire & Water Eng., 74: 399, August 29, 1923. Majority of water works engines built in Britain today are of three cylinder, three crank, triple expansion, rotative direct acting type, general arrangement of which follows closely the Reynolds engine, as favored by American engineers: they are built for highest possible duty. The Worthington non-rotative compensated engine is installed in a fair number of units, and since its original introduction from America, has been well thought of by British engineers; but the rotative type, as outlined, is generally preferred. Where these engines are unsuitable, or too costly, compound engines of horizontal side-by-side type, with plunger pumps operated by the piston tail rods, are used to some extent; the American type, with pumps in front of the steam end, and flywheel in between, is practically unknown in Britain. Centrifugal pumps for high lifts are being appreciated more than formerly, for those plants where electric power is cheap. American practice of steam turbine driven centrifugals has never "caught on" in Britain, but the Diesel engine is coming to the front, especially for bore-hole pumps with vertical shaft driven by gearing. The Metropolitan Water Board (London supply) have also a number of Diesel engine-driven ram pumps of considerable capacity for pumping, in the main, to high level service reservoirs. Illustrations show English built pumping engines in the Palermo pumping station in Buenos Aires and in the Hong Kong water works. The large engines are designed for the most economical operation when combined with a modern boiler plant; a steam consumption of about 11 pounds per pump horse power is generally called for, this being the method whereby most British engineers measure the efficiency, as opposed to foot pounds of work per pound of coal.—*Geo. C. Bunker.*

**What Shall It Be, Meters or Additional Supply?** NICHOLAS S. HILL. Fire & Water Eng., 73: 1013, May 23, 1923. There are two primary reasons for use of meters. First, that volumetric measurement is the only fair and logical basis on which to sell water, because only thus can gross inequalities and discriminations be avoided. Second, metering is the only way yet found of restricting needless waste. Idea that meter restricts legitimate use of water is erroneous. Water is cheapest of all necessities of life supplied to residents of towns and cities. Meter system has the advantage that it does not restrict consumer in installation of adequate plumbing equipment, as fixture rates do; consumer soon learns that amount of water consumed is not proportional to number of fixtures installed, so long as plumbing is kept from leaking. All that meter does, is to restrict needless waste which occurs on all unmetered systems. If one were to assume that the only reason for installation of meters was saving in capital outlay and operating expenses effected thereby, he would commit a grievous error. As a practical matter, conditions under which water works in the United States have been developed in last 30 years have greatly changed; need of stopping waste, for purpose of conserving available sources of supply, has become more important and is becoming more and more important each year. Another sound argument for introduction of meters is, that only thus can a water department be efficiently operated. The water works manager operating with master meters which register amount of water delivered into distribution system, but with no means of measuring water actually consumed, is very seriously handicapped in determining sources of waste; whereas, if all consumers are metered, he can sum up consumption, as measured by consumers' meters, compare revenue-bearing water consumed with that pumped, and take steps to remedy intermediate losses. No basis exists for a rational system of flat charges. A scale of rates is at best a makeshift. The front-foot charge has the least to recommend it. No correlation can be established between front-footage and consumption of water. Of flat rate methods of charging, the fixture rate is the least illogical; but use of water from fixtures will vary enormously with different consumers. The amount of water for which consumer pays a given sum, with fixture rate, depends upon mere whim. Great evil of all flat rate charges is that they place no premium upon restriction of waste. General principles for proper rate structure are given. Saving effected by installation of meters in East Orange, N. J., is discussed; also the anticipated saving in Baltimore, Md.—*Geo. C. Bunker.*

**Let the Citizens Know What the Water Works Really Does.** J. E. GIBSON. Fire & Water Eng., 74: 11, July 4, 1923. General information concerning water rates, collections, and periods of meter readings. Thorough discussion of monthly, versus quarterly, readings of meters and issues of bills is included; conclusion reached, that quarterly reading and billing has met requirements of efficient management in Charleston, S. C. Six tables contain useful information.—*Geo. C. Bunker.*

**The Square Deal in Water Works Valuation.** C. P. LAMBERT. Fire & Water Eng., 74: 61, July 11, 1923. General discussion of equitable method of valuation of privately owned water company.—*Geo. C. Bunker.*

**The Proper Way to Figure Hydrant Rentals.** A. S. HOLWAY. Fire & Water Eng., 74: 103, July 18, 1923. Brief outline is given of the three general methods of computing cost of fire protection service: the Comparative Method; the Excess Method; the Proportional Method. Determination of an equitable charge for fire protection service in Oklahoma City is cited as example. Cost of such service should be paid by taxation.—*Geo. C. Bunker.*

**The Municipal Water Works System Versus the Privately Owned Plant.** W. A. STANFIELD AND J. W. KELLY. Fire & Water Eng., 74: 106, July 18, 1923. Mr. Stanfield argues in favor of municipal ownership, and Mr. Kelly in favor of private ownership.—*Geo. C. Bunker.*

**Use of Reinforced Concrete on Small Reservoirs and Tanks.** JOHNSTONE-TAYLOR (England). Fire & Water Eng., 74: 118, July 18, 1923. Mainly to show how tanks may be made watertight without linings. Author is not in favor of applying asphaltic or waterproofing compounds. Experiments carried out in England at National Physical Laboratory showed that even rich concrete was porous under head of 20 feet, but degree of porosity decreased after several weeks, less by supposed silting up of pores than by swelling of concrete. Impermeability does not depend so much upon richness of mix as upon proper proportioning of sand and aggregate. Plastering interior surface with a very rich mixture is unsatisfactory, as the lining invariably breaks away from the concrete. The now recognized procedure is, to cast a rich face on concrete itself. Base concrete may be a 1-2-4 mix, and water face a 1-1-2 mix, 1½ in. thick. Latter is placed first against timber sheeting and a temporary sheet iron plate resting against the reinforcement. Base concrete is immediately rammed in, and iron plate withdrawn, the two sections being then thoroughly puddled together. Illustrated.—*Geo. C. Bunker.*

**Example of Well Designed Small City Water System.** S. A. SULENTIC. Fire & Water Eng., 74: 122, July 18, 1923. Brief description of improvements made to water system. Illus.—*Geo. C. Bunker.*

**How Mains Should Be Laid under Railroad Tracks.** EMERY E. FERGUSON. Fire & Water Eng., 74: 153, July 25, 1923. It is standard practice in Charleston, W. Va., to case mains running under railroad tracks, using old wrought iron or steel pipe. Smaller casings, under 4 inches, are driven with hammers and wooden blocks or by pipe driving jacks. Description is given of installation of 10-inch casing for 6-inch main. Illustrated.—*Geo. C. Bunker.*

**Unit Cost of Laying Cast Iron Pipe.** Fire & Water Eng., 74: 165, July 25, 1923. Table, taken from twenty-first annual report of DAVID A. HEFFERNAN, Sup't. of Water Dep't. of Milton, Mass., shows unit costs of installing fifteen 6-inch and one 12-inch cast-iron mains. Cost per foot varied from $1.91 to $4.15.—*Geo. C. Bunker.*

**Why Water Works Men Favor Auto Pumper for Fire Pressure.** J. ARTHUR JENSEN. Fire & Water Eng., 74: 199, August 1, 1923. Adequate hose pres-

sures are more economically attained by motor pumpers than by increased pressure in the water system. Fire apparatus is more flexible, mobile, and efficient for fire fighting than with ordinary hydrant pressures. Risk is obviated of applying additional pressure to water mains, services, and plumbing, at critical hours. Statistics indicate that about 80 per cent of water plants do not increase their pressures for fires, and that fire departments do not depend upon water systems for such pressures, but develop their own pressures either by motor pumps, separate high pressure systems, or both. Data are given affording comparison of cost of fire engine pumping with that of increasing the pressure in water system.—*Geo. C. Bunker.*

**Taking the Guesswork out of Water Leakage.** E. E. BANKSON. Fire & Water Eng., **74**: 207, August 1, 1923. Examples of leaks located by use of Pitometer and Geophone in Piedmont, W. Va., and in Patton, Pa. Combination of Pitometer with Geophone can produce most surprising results in finding leaks in hands of an experienced man. Illustrated.—*Geo C. Bunker.*

**An Excellent Water Company Advertisement.** Fire & Water Eng., **74**: 261, August 8, 1923. Reproduction of newspaper advertisement of Davenport, Ia. Water Company, showing what average American citizen does with his income. Only 0.21 per cent is spent for water supply.—*Geo. C. Bunker.*

**Keeping Tab on Water Consumed by Private and Industrial Users.** Fire & Water Eng., **74**: 262, August 8, 1923. Letter from HARRY ELLSWORTH, Supt., Water & Light Dept., Meadville, Pa., shows how consumption of water distributed among following classes:—domestic, commercial, industrial, railroads, city, schools, and sprinkling. Data cover the year 1922 by quarters. —*Geo. C. Bunker.*

**Cutting Costs with an Automatic Booster Pump.** ORMOND A. STONE. Fire & Water Eng., **74**: 299, August 15, 1923. Description of the main booster pump station of the water works of Hayward, Calif. Water from wells is delivered into 100,000 gallon concrete pumping sump by air lifts. In booster station are two direct connected motor driven centrifugal pumps, with capacity of 500 g.p.m. against head of 305 feet, motors of which are controlled by automatic starting compensators, operated through float switches installed in pumping sump. In installation was included an air chamber so designed as to limit rise in pressure in the line, in case of instantaneous stoppage of pumps, to normal pumping pressure. Plant has been in successful operation for two years, and, with exception of periodic oiling, has required no attendance. Pumping costs were reduced 3½ cents per 1000 gallons by the new equipment, or approximately 30 per cent. Illustrated.—*Geo. C. Bunker.*

**Keeping Down the Operating Cost of Standby Pumping Units.** E. M. PROCTOR. Fire & Water Eng., **74**: 345, August 22, 1923. For the small water works plant pumping below 4 million gallons per day, the gasoline engine driven centrifugal pump has become standard equipment. Gasoline engines are built to operate at speeds between 1000 and 1400 r.p.m. If equipped with

storage battery electrical starting equipment, they can be started almost immediately and have proved very satisfactory. Fuel consumption is usually about 1 pint of gasoline per hour; although sometimes not much over ½ pint. A pump supplying 1000 gallons per minute at 100 pounds pressure will cost $2.71 per hour, or 4.5 cents per 1000 gallons, with gasoline costing $0.31 per imperial gallon. This is a high cost of pumping, but when one takes into consideration the capital costs of the various units as well as the comparatively short time which this pump will be operated, the operating costs of the gasoline driven pump are, without doubt, the least. A centrifugal pump of 4 million gallons per day capacity, against 230 feet head, connected to a G. R. C.-8 Sterling engine, costs about $7,000.00, f.o.b. factory, or figuring pump and engine together, cost per horsepower is about $25.00. For standby unit in a larger plant it is doubtful if one could improve upon semi-diesel oil driven engine, direct connected to a generator, to supply power in an emergency for motors of pumps. Cost per horse-power for semi-diesel oil engine is about $100.00. Illustrated.—*Geo. C. Bunker.*

**Some Practical Results of 100 Per Cent Metering.** A. E. WALDEN. Fire & Water Eng., 74: 349, August 22, 1923. Advantages of meterage over flat rate system are brought out forcibly and pertinently. Proof of waste under flat rate system is easily obtained by examining statistics of cities where change from flat rate to metered rate has been made. Reduction in pumpage of 40 to 50 per cent is usual. Under flat rate system, cost of effective operation, inspections, pitometer tests, waste surveys, etc., will more than offset cost of meters. Unlike flat rate inspections, meters are on the job all the time. No public utility would be considered on a sound operating basis, if its unaccounted-for product exceeded 10 per cent of its total product; yet most water departments, including even those privately operated, will show at least 40 per cent of total pumpage unaccounted for. Particularly is this the case under flat rate systems, where water consumption generally varies from 150 to 200 gallons per day per capita. Under metered rates, the consumption is, in general, 40 to 50 gallons. Thus there is four times as much water used under a flat system. This means providing reservoirs to care for a storage four times greater. Four times greater capacity is required in pumps, in purification plant, and in distributing system. Operating expense of pumping, purifying, and distributing a four fold water supply is also very considerable. In case of Baltimore, Md., it is possible to reduce water consumption from 170 to 85 gallons per day per capita. Immediately, capacity of system is doubled for same population, and, instead of assummed life of ten years before additional capital expenditures required, there would be twenty years. Present filtration plant can thus be made to supply needs of population increased by 40 to 50 per cent. If waste is not stopped, plant must be increased. Cost of new units for filtration plant will exceed investment in meters. Cost of wasted water is much greater than the fixed and operating charges of a meter system. Cost of purchasing and installing would be distributed over a five-year period, whereas deferring use of meters reduces margin between ample and insufficient supply. The city would have protection, in addition, against cost of handling extra sewerage caused by the present waste. City departments as well as private users, waste water under present system.—*Geo. C. Bunker.*

**A New Automatic Valve that Regulates Flow.** F. JOHNSTONE-TAYLOR (England). Fire & Water Eng., 74: 350, August 22, 1923. A new design of valve to prevent excessive flow of water through a main. The pipe line is considerably contracted at point of insertion of valve, and utilizing Venturi meter principles, closure at any desired rate of flow is ensured. By means of a Pitot tube connection, a break on down stream side will close the valve. Illustrated.—*Geo. C. Bunker.*

**New Filtration Chamber.** Fire & Water Eng., 74: 359, August 22, 1923. A newly invented filtration chamber is constructed of cast iron panels, with inner surfaces enameled, so that tendency to become coated is reduced to minimum, and surfaces can be cleaned at minimum expense. Edges of the panels are flanged, can be readily machined and drilled, so they can be bolted together with simple packing strips between, and water tight joints secured. Illustrated.—*Geo. C. Bunker.*

**Some Practical Pointers on Rapid Sand Filter Operation.** WILLIAM D. HATFIELD. Fire & Water Eng., 74: 395, August 29, 1923. A nontechnical paper for the water works superintendent who is not a chemist.—*Geo. C. Bunker.*

**Sewage Works Analysis and Standards of Purification.** J. H. GARNER. Surveyor, 61: 393–5, 1922. The Royal Commission Test, comprising absorption of dissolved oxygen in five days at 65°F., was studied at length, using dilution water from various sources. It was impossible to get concordant results when different dilution waters were used, even though the pH was adjusted to the same valve. Higher results were obtained at a pH of 9.0 than at 6.5. Distilled water, however, gave high results at a pH of 6.0. Blank tests on all dilution waters showed no appreciable loss of oxygen. The difficulty seems to be in the composition of the water used. The use of distilled water seems desirable.—*F. W. Mohlman.* (*Courtesy Chem. Abst.*)

**Progress in Water Purification.** A. C. HOUSTON. Surveyor, 61: 407–10, 1922. Houston claims it is frequently difficult to get first-class bacteriological results with rapid sand filters, and advocates double filtration, such as, preliminary filtration with rapid filters at 100 to 200 gallons per square foot per hour, without coagulants, followed by slow sand filters at an increased rate of 3 to 6 gallons per square foot, per hour. Storage is very effective in purifying the Thames River water in the Chelsea reservoirs. Experiments indicated that typhoid bacilli could not be isolated from this water after from five to nine weeks, although initially, millions per cc. were present. "Cultivated" or sub-cultured bacteria were much more resistant than those freshly isolated from feces. At temps. below 10°C., typhoid bacilli were isolated after eight weeks; at 18°C., not after three weeks. Algal growths are troublesome in stored waters, but tastes and odors produced by them can be removed by adding five pounds potassium permanganate per million gallons. The algae are destroyed best by copper sulphate. Excess lime sterilization is effective for bacterial removal, but has not been used as widely as chlorination. Houston recommends super-chlorination followed by de-chlorination with sulphurous acid or $KMnO_4$.—*F. W. Mohlman.* (*Courtesy Chem. Abst.*)

**Selection of Pumping Equipment for Station Economy.** FRANK A. MAZZUR. Amer. City, **30**: 133-136, 1924. (From paper before New England Water Works Assn.) Discusses relative merits of small pumping units (about 3 m.g.d.) of various types including (*a*) Crank and fly-wheel, (*b*) Steam Turbine, (*c*) Water-Driven Plunger, (*d*) Direct-connected centrifugal, (*e*) Oil engine drive. Comparative cost estimates are given, based on eight, sixteen and twenty-four hours operation. Assuming 12 per cent depreciation on steam units and 15 per cent on other types, with coal at $8.50 and electricity at 2, 1.7 and 1.64 cents per kw.h. respectively, there is little choice on eight hour basis; on sixteen hour basis, oil engine is most economical, with steam next: on twenty-four hour basis oil engine saves $3,000 per annum over steam equipment, and $9000 per annum over electric pumping. Detailed cost figures accompany the paper.—*W. Donaldson.*

**Typhoid Fever Death Rate Lower than Ever.** ANON. Amer. City, **30**: 136, 1924. Figures quoted from Department of Commerce, as of December 28, 1923, show decline of typhoid death rate from 35.9 per 100,000 population in 1900 to 7.5 in 1922, some progressive cities have rate of less than 1 per 100,000.—*W. Donaldson.*

**Modern Carthage Builds a Forest.** G. H. COLLINWOOD. Amer. City, **30**: 147-149, 1924. Describes the program under which village of Carthage, N. Y., is reforesting its water works catchment area of 2000 acres. Denuded area, acquired twenty years ago, eroded badly, filled reservoirs with silt and necessitated construction of settling basins. In 1913, 20,000 four-year-old transplants of Scotch pines, obtained from nurseries of State Conservation Commission, were made at cost about $8.00 per acre. Recently, several thousand white pines have been planted, with special precaution against the blister rust. Trees are planted 6 ft. apart, in rows, making about 1210 per acre. At present 500 acres have been planted, but program calls for reforestation of entire watershed within next ten years. Area expected eventually to yield a million feet of lumber annually. Author includes information regarding other reforestation work in New York State, based on investigation by Bureau of Municipal Research. Twenty-six cities control 220,000 acres in connection with water supplies. Of this acreage, 8000 acres have been reforested by municipalities; 80,000 acres are wooded; 3000 acres are farm land; 130,000 acres need to be reforested. Estimated cost of latter is $1,000,000, while estimated yield, at end of 40 years, is 2,600,000,000 board feet of lumber, worth at current prices $39,000,000, or $975,000 per annum. An acre of forest should yield continuously 500 board feet per annum. Reforestation protects the water supply and brings a monetary return, besides esthetic advantages.—*W. Donaldson.*

**Relation of pH to Filter Plant Control..** WM. D. HATFIELD. Ind. Eng. Chem., **14**: 11, 1038, November, 1922. Quantity of alum required to produce distinct floc in water is governed primarily by H-ion concentration (pH) and not by matter in suspension (turbidity). pH values of raw water at Highland Park, Mich., vary from 7.7 in winter to 8.4 in summer. During

summer, coagulation begins at pH. 7.8 and is fair at 7.6. In winter, pH must be reduced about 0.2 to 0.3 below the summer figures to produce a similar floc. Most satisfactory zone of coagulation was between pH 7.6 and 6.6, but from standpoint of maximum efficiency of plant operation, pH 7.2 to 7.3 was best. Since raw water is not highly polluted, it is more economical to operate plant at about pH 7.4 to 7.6, thereby using less alum and a little more wash water. Gillespie's method (J. Am. Chem. Soc. **42**: 743, 1920) of pH determination, "without buffers," is recommended for water works laboratories. Two sizes of filter sand are in use at the plant; Red Wing, effective size 0.44 mm., uniformity coefficient 1.50, and Cape May, effective size 0.34 m., uniformity coefficient 1.62. Both gave same efficiency in bacterial removal, but longer runs were obtained, and less wash water used, with the coarser sand. (NOTE: This water does not contain color).—*Linn H. Enslow.*

**Radio-activity of Waters Examined in the Bureau of Chemistry.** W. W. SKINNER AND J. W. SALE. Ind. Eng. Chem., **14**: 10, 948, Oct. 1922. From results in case of all waters, foreign and domestic, which have been analyzed, and also from published data, it may be concluded that shippers are not justified in making statements on labels which could induce prospective consumers to purchase the waters because of their radioactivity. The greatest radioactivity of a temporary nature was found in a water from a warm spring in Massachusetts. Permanent radioactivity was found in greatest measure in deep well in northern Ohio. To obtain daily dose (2 micrograms) prescribed by American Medical Association as a minimum, patient would have to consume 2810 gallons of the warm spring water or 1957 gallons from the Ohio well. —*Linn H. Enslow.*

**Effect of Hydrogen Ion Concentration upon Precipitation of Vegetable Tanning Materials.** J. ARTHUR WILSON AND ERWIN J. KERN. Ind. Eng. Chem. **14**: 12, 1128, December, 1922. Rate of filtration of tan liquors is markedly affected by change in hydrogen-ion concentration. A solution of quebracho extract used for the experiment contained 67 per cent tannin, 8.8 per cent insoluble matter, and had pH value of 4.6. Lowering of pH with hydrochloric or sulfuric acid *increased* insoluble matter and rate of filtration. Raising of pH with alkalies resulted in a *decrease* of insoluble matter but an *increase* in the rate of filtration, both proceeding continuously in case of sodium hydroxide. With lime, instead of soda, as the alkali, an abrupt change occurred at neutral point, pH 7.0: further addition of lime continuously precipitated tannin in *increasing* amounts: rate of filtration received a "jolt" at pH 7.2, rapidly falling off to one-third, with rapid clogging of filter until reaching pH 8.2: at this point, a reversal set in and rapid *increase* was observed: at pH 9.2, the whole of the loss had been regained. Further addition of lime to pH 10.55 increased rate of filtration only slightly, but insoluble matter increased to 80 per cent above that at pH 9.2.—*Linn H. Enslow.*

**Water Supplies of the Panama Canal.** GEO. C. BUNKER. Water and Water Eng., January 1923. The U. S. Government, through Municipal Engineering Division of The Panama Canal, operates three water purification plants which

supply the cities of Panama (59,458 population) and Colon (29,000 population) and the Canal Zone towns, villages, military reservations and naval bases (27,700 population). To this relatively constant population of 116,158 must be added the shipping which passes through the Canal and takes sterilized filtered water at Cristobal or Balboa. The average supplied to ships in 1922 was 9,000,000 gallons per month. Colon and Panama are 100 per cent metered at the services, as well as through a large Venturi Meter; 88,458 people are supplied through 3,650 services with, on an average, 4,890,000 g.p.d. The per capita consumption is 57 g.p.d. which stands out in bold contrast to the per capita consumption of 280 g.p.d. in the Canal Zone which is not metered, where 27,700 people consume 7,700,000 gallons per day. Filter plant capacities are (1) Miraflores, 17.0 m.g.d.; (2) Mt. Hope, 8.0 m.g.d.; (3) Agua Clara 2.5 m.g.d. Miraflores filters have false bottoms of concrete through which project ¾ in. brass pipes on 6 inch centers into filter. The ends of these pipes are bent downward at 180°. Brass strainers originally attached to each pipe have been removed entirely. Original gravel bed was replaced with one 24 inches in depth, using as first layer, hand placed gravel of 2½ inches diameter and larger. Seven years of service have shown the Miraflores false bottom filters to be a success. Effective washing is maintained with less than 3 per cent of wash water. Contrary to expectation, algae in Canal Zone reservoirs have never caused particularly objectionable tastes or odors, although at times responsible for very short filter runs. None of the watersheds feeding the storage reservoirs are inhabited. A caretaker and gang are continuously employed in keeping feeder streams and shore line clear of growths. The most serious matter affecting deep tropical reservoirs is the presence of putrefying organic matter at 10 feet, or more, below the surface. By far the least desirable raw water is that from Agua Clara Reservoir. Color will vary from 8 to 152 parts, iron from 0.21 to 3.0 parts, and oxygen consumption value from 1.2 to 9.8 parts. Treatment is: soda ash at rate of 37 pounds per million gallons applied to raw water main 200 feet back of aerator: alum at 350 pounds per million gallons applied 17 feet back of aerator. Treated water then passes aerator, mixing chamber, and coagulation basins. For most effective coagulation, a pH of 5.5 is maintained, with a resulting 4 p.p.m. alkalinity (erythrosine) and 4.5 parts free $CO_2$. After filtration, lime equivalent to 15 parts of alkalinity is applied; a pH. of 9.0, with 5 parts of $CaCO_3$ resulting. Chlorination of the filtered water is practised at all three plants. Lead is attacked by Agua Clara filtered water (pH 9.0); old pipe (0.10 p.p.m. lead in tap water) much less than new (0.5 p.p.m. lead in tap water). Lead services, therefore, are not approved. Chemically, the Canal Zone filtered waters are all that could be desired for domestic or industrial use. Cost of purification per 1000 gallons runs as follows: 1.45 cents at Mt. Hope; 2.79 cents at Miraflores; 3.73 cents at Agua Clara. A graduate chemist or engineer is placed in charge of each plant as resident superintendent.—*Linn H. Enslow.*

**Utilization of the Salts of Organic Acids by the Colon-Aerogenes Group.** STEWART A. KOSER. Jour. Bacteriology, **8**: 5, 493, September, 1923. Many organic acids offer source of carbon sufficient to support development of organisms of colon-aerogenes group. Media containing a source of nitrogen,

certain inorganic salts, and organic acids or their salts, but no other source of carbon, will support growth of one or another of this group. Sodium salts of acetic, succinic, malic, lactic, mucic, and glyceric acids support abundant growth of all colon and aerogenes cultures. Others, *n*-valeric, isovaleric, *n*-caproic, oxalic, salicylic, and ortho-phthalic, did not support growth and gave negative results. Several acids support growth of fecal B. coli, but not of aerogenes, and vice versa. Propionic acid permitted a moderate growth of most fecal B. coli strains while the B. aerogenes cultures, with one exception, were negative. The most striking results are obtained from citric acid, in which fecal B. coli consistently failed to develop, while B. aerogenes multiplied readily. The hydrogen-ion concentration of the media was reduced by aerogenes (pH 6.8 increased to pH 8.4 to 9.0), while media inoculated with B. coli were unchanged. Citrate somewhat retards the rate of growth of aerogenes. Citrate concentrations of 0.10 to 0.50 per cent were found to be the most desirable range. Below this, insufficient carbon is supplied; above it, inhibition is too great. Sodium, ammonium, or potassium citrates produce identical results.—*L. H. Enslow.*

**Penetration of Bacteria Through Capillary Filter Spaces.** STUART MUDD. Jour. Bacteriology, **8**: 5, 459, September, 1923. When a liquid containing bacteria is drawn through a filter under circumstances in which a few organisms may or may not pass, motility may be a critical factor in determining passage. Motility aids passage, both in purely mechanical ways, as well as by combating tendency of organisms to adhere to pore walls. Vibrio comma repeatedly showed itself able to pass, by its own powers of growth and locomotion, through a layer of sand in shorter time than V. percolans. V. comma is held back by a Berkefeld filter, while V. percolans passes, because the comparatively small size of the latter offsets its lesser power of locomotion. The intergranular diameters are therefore of critical importance in determining the penetrability of filters by bacteria. Tortuosity, length of passage, and adhesion, as well as narrowness of passage doubtless play their part in holding back bacteria.—*L. H. Enslow.*

**Sanitation in Minnesota: Report of Committee on Sanitation, Minn. Surveyors' and Engineers' Society.** The Bulletin, Minn. Federation of Architectural and Engineering Societies, **8**: 10, 18, October, 1923. During 1920 and 1921 water service connections in cities and villages of Minnesota increased at rate of 4.5 per cent per year. Approximately 400 public water supplies in the state; 38 supplies from lakes or streams, wholly or in part, 20 receiving treatment, and 18 none. Untreated supplies dangerous from health standpoint; State Board of Health urges substitution of underground sources or treatment. Several untreated supplies were undergoing sanitary betterment at time of report.—*E. S. Chase.*

**Report of Bureau Sanitary Engineering.** C. G. GILLESPIE, Director. Quarterly Bulletin, California State Board of Health, January-March, 1923, p. 37. In damage suit against city of Pittsburgh, Cal. on account of the typhoid in that city during June and July, 1920, due to neglect in keeping chlorin-

ation works in comission, Judge Plummer of Superior Court held it incumbent upon city to use all reasonable precautions to render the water fit and wholesome and to give it treatment necessary. Damages were awarded in the amount of $32,921.29. (*Cf.* JOURNAL, 10: 6, 1140; 11: 2,503.)—*E. S. Chase.*

**The Liability of Municipalities for Typhoid Resulting from Polluted Water Supplies.** Indiana State Board of Health, Monthly Bulletin 26: 5, 67, May, 1923. Abstract of decision of Supreme Court of Minnesota. Court held that city of Mankato was liable for negligence in operation and pollution of its water supply, and was subject to damages. Court in its decision stated "It is obvious that a sound public policy holds a city to a high degree of faithfulness in providing an adequate supply of pure water; nor does it appear why the the citizens should be deprived of the stimulating effects of fear of liability on the energy and care of its officials, nor why a city should be exempt from liability when a private corporation under the same circumstances should be held responsible for its conduct and made to contribute to the innocent persons it may have damaged." Case of Keeler and Flannagan vs. City of Mankato.—*E. S. Chase.*

**How Conn. Safeguards Water.** Conn. Health Bulletin, 37: 11, 17, November, 1923. Brief popular exposition of chlorination of public water supplies.—*E. S. Chase.*

**Odors and Tastes in Water.** Conn. Health Bulletin, 37: 12, 22, December, 1923. Popular explanation of sources of tastes and odors in water supplies.—*E. S. Chase.*

**Report on the Examination and Control of Water Supplies.** Biennial Report, State Board of Health of New Hampshire, 1921–1922, p. 21. Work covered analyses of water samples and inspections of supplies. Special attention paid to lead and zinc content. 380 samples examined for lead; of which 71, or 18.7 per cent showed quantities in excess of 0.5 p.p.m. Supplies certified for railroad use are listed. Since 1901, general sanitary improvements on watersheds have been instigated; 7 municipal plants and 16 chlorination apparatus have been installed. Considerable detail given relative to public water supplies of New Hampshire, particularly that of Manchester. State Board requires double check valves between industrial supplies and public supply mains where cross connections exist.—*E. S. Chase.*

**Report of Division of Engineering and Sanitation.** Ill. State Dept. of Public Health, 5th report (year ending June 30, 1922), p. 103. Outline of work of division in connection with sanitary protection and improvement of public water supplies in Illinois. Graphical presentation is made of population served by public water supplies by decades. In 1922 some 494 municipal or institutional water supplies in Illinois served population of approximately 4,700,000. Special efforts were made by Division to assist in operation of water purification plants. During year covered, there was but one outbreak of water borne dysentery, and one of typhoid. Report contains summary of action taken relative to certification of water supplies for railroad use.—*E. S. Chase.*

**Control of Stream Pollution.** C. F. DALTON. Michigan Public Health, 11: 8, 305, August, 1923. Reprint of report of Committee on Sanitary Engineering, conference of State and Provincial Health authorities, Washington, D. C., May, 1923; from Amer. Jour. Pub. Health, August 1923.—*E. S. Chase.*

**Public Water Supply.** H. E. MILLER. Health Bulletin, N. Carolina State Board of Health, 38: 6, 8, January, 1923. Deals with quality of water supply; extracts from laws of North Carolina, covering sanitary control and protection of public water supply. Board of Health has general oversight, and authority to make rules and regulations to prevent contamination of, and to secure purification for, water supplies. Disobedience to rules and regulations are punishable by fine or imprisonment. Water supply and sewerage plans must be approved by the Board.—*E. S. Chase.*

**The Business Side of Public Supply.** H. E. MILLER. Health Bulletin, No. Car. State Board of Health, 38: 11, 15, November 1923. Points out magnitude of water supply business of North Carolina. 152 water supplies in the state represent combined investment of $25,000,000 and annual revenue of $2,500,000. Includes map of North Carolina, showing location of its public water supplies, and giving condensed data relative to sources of supply, treatment afforded, and laboratory control.—*E. S. Chase.*

**New Health Laws and Regulations of Ohio.** Ohio's Health, 14: 1, 2, and 3, January, February and March, 1923. Sections relating to water supply are given on pp. 10–14; those relating to railroad water supplies on p. 29.—*E. S. Chase.*

**West Virginia's Progress Toward Pure Water Supplies.** E. S. TISDALE. Quarterly Bulletin, West Va. State Dept. of Health, 10: 13, 217, July, 1923. Popular article, showing improvement in water supplies in West Va. in past few years.—*E. S. Chase.*

**First Biennial Report by the State Dept. of Health of Washington, 1921 and 1922.** Report of sanitary engineers, pp. 101 seq. Includes regulations of Department, governing water supplies and sewage disposal. Lists water and sewage purification works in State, and describes in considerable detail many of the public water supplies. It is interesting to note that State Health Dept. of Washington institutes through office of prosecuting attorney, criminal action against water companies failing to obey orders relative to installation of purification plants. Double check valves of the F. M. type, for separation of auxiliary mill supplies from municipal supplies, appear to be approved. Typhoid death rate in Washington was 5.6 in 1921, and 5.0 in 1922, per 100,000 population.—*E. S. Chase.*

**Special Report Relative to Water Supply for the City of Lawrence and the Town of Methuen.** Mass. Dept. of Public Health, March, 1923. Legislature in 1922 directed Department of Public Health to investigate water supply needs and resources of City of Lawrence and town of Methuen, and to determine

best method of supplying these municipalities with water and protecting the purity thereof. Developing of nearby streams, other than the Merrimac, is not advisable at present, on account of cost. The possible development of joint project, to include other nearby municipalities, is discussed. More extended investigation is recommended.—*E. S. Chase.*

**The Treatment of Municipal Water Supplies.** N. J. Public Health News 9: 2, 51, January, 1924. Good general discussion of water treatment with special reference to New Jersey conditions.—*E. S. Chase.*

**The Operation of Wheeler Filter Bottom.** N. J. Public Health News 9: 2, 64, January, 1924. Discussion of above, as installed at two filter plants in N. J. At one plant, after 18 months operation, cement spheres were found to have changed into a variety of irregular figures. In making repairs, cement spheres are replaced by earthernware spheres of same diameter, and gravel is increased from 6 to 12 inches.—*E. S. Chase.*

**Water.** Geo. W. Simons, Jr. Fla. Health Notes, 16: 2, 24, February, 1924. General discussion of water supply, with some data relative to underground waters in Florida.—*E. S. Chase.*

**Present Day Practice in Chemical Treatment of Water** (in Holland). Dr. A. Massink. Water en Gas, January 15, 1924. Many interesting and important refinements, introduced in recent years, find but small applicability to conditions in Holland, where, frequently, water as pumped from the well is either quite suitable for consumption, or can, without difficulty, be rendered so by removal of iron and/or manganese. The stimulus to improved practice, so notable in America, is largely lacking. Chemical treatment is conveniently classified as: A, removal of undesired constituents, without addition of chemicals; B, same; with addition of chemicals; and C, sterilization. Foremost under A belong deferrization and demanganization. To Oester and Piefke, respectively, we owe the principles of spraying and of coke percolation. In most cases, these suffice, when followed by, first, either sedimentation basins or roughing filters, and then, fine sand filters: but some waters are refractory. Sedimentation may be conveniently studied in a cask in which are suspended a series of siphons set to different depths, rendering available at any time a sample from any desired stratum. The iron, evenly distributed at the start, will, in general, concentrate towards lower levels with lapse of time. In the case of one water examined, notwithstanding very imperfect sedimentation, a faultless filtrate resulted; representing a transition case between those waters from which iron readily flocks out and those from which it cannot be removed without adding chemicals (class B). Iron removal is, largely, a colloid chemical problem. Flocculation tends to be retarded by low electrolyte concentrations, and accelerated by higher, which imply, usually, preponderance of bicarbonate among the anions present. Notable among other factors, is the highly prejudicial influence of certain organic substances. Demanganization is the more difficult problem; adjustment of hydrogen-ion concentration is here important. Explanation is offered of known advantages of "manganese sand"

which has already served for demanganization. Like iron, manganese tends to be more difficult to get rid of, according as preponderance of bicarbonate diminishes; as with iron, too, addition of chemicals may eventually be needed. Carbonic acid yields to intensive aeration, and both oxygen and carbonic acid, to vacuum degasification (sometimes necessary for soft water, which easily becomes aggressive). For iron-free soft water, aggressivity removal is conveniently effected by Scheelhaase's method of using marble in supporting layers under filter; this might perhaps be more appropriately included under next heading. Under B, softening processes are most important, either (1), lime—soda, leaving a small residual hardness, or (2) permutite, leaving zero hardness. Alum coagulation is usual practice for decolorization. Both turbidity and color, but especially former, range considerably higher in America than in Holland, and opportunity is taken to render tribute to work done on coagulation in America, this JOURNAL receiving special mention in this connection. Lack of concordance in conclusions reached is still apparent. Clark's new process and iron—lime coagulation are described. Under C are discussed ultra-violet radiation, ozonization, and chlorination; last-named, at some length. Supplies needing sterilization are comparatively infrequent in Holland, and progress of chlorination, correspondingly slow. American work on chlorination and its control is duly appreciated. Advantages of Chlorination for swimming pools are pointed out. Finally, Houston's "excess lime" method receives mention. Bibliography includes 11 references.—*Frank Hannan.*

**Hydrobiological Conditions in Rijnland (Holland).** DR. G. ROMIJN. Verslagen en Meded. betref. de Volksgezondheid, 1924, 2, 107. A more or less occult phase of the ceaseless strife for her existence which Holland has to wage with the inexorable North Sea, is here revealed; namely, invasion by salt water of her innumerable waterways. This tends to render the water useless alike for domestic supply, industry, agriculture, or live stock; and the added sulfate is readily convertible into highly offensive sulfuretted hydrogen. The pure dune supplies are limited, and therefore precious; they must be guarded by the utmost possible utilization of surface water. The results of hydrobiological surveys are detailed, and their great value pointed out as indicators of zones where brackish water is being pushed back and vice versa, etc. Every available centimeter of head is jealously watched and made to do its utmost in keeping out the enemy. Opinion is expressed that, from the hygienic standpoint, almost no expense could be too great, which would effectually bar out the salt water.—*Frank Hannan.*

**Chlorination of Water.** DR. A. MASSINK. Tijdschr. v. Vergelijkende Geneesk. enz., 9: 1–2, 1923. Widespread adoption in America and Germany is noted; is now coming into use in Holland. Quantitative tests on Maassluis supply indicated that dosage at rate of either 0.3 or 0.5 p.p.m. would reduce bacterial counts to negligible limits in course of thirty to sixty minutes; in the case of smaller, but not of larger, dose, vigorous aftergrowth manifested itself within twenty-four hours. Since ferrous iron, if present, is at once oxidized to ferric, at expense of chlorine, it is logical that deferrization precede chlorina-

tion. Two series of taste tests, with eight and nine observers, respectively, resulted in correct decisions as to presence or absence of chlorine, with dosages of nil and 0.5 p.p.m. in both series, and intermediate dosages of 0.3 and 0.25 p.p.m., respectively, in just over 60 per cent of trials in each case. Considerably rarer was the ability to distinguish lesser from greater chlorine dose.—*Frank Hannan.*

## NEW BOOKS

**The Chemical Examination of Water, Sewage, and Foods, Etc.** J. E. PURVIS AND T. R. HODGSON. 2nd. ed. revised. Cambridge: University Press. 20s. Reviewed in Chem. Trade J., **70**: 600, 1922 .From Chem. Abst., **16**: 2379, July 20, 1922.—*R. E. Thompson.*

**Boiler Chemistry and Feed Water Supplies.** J. H. PAUL. London: Longmans Green & Co. 252 pp. 15s. Reviewed in Municipal Engineering, **73**: 84, 1924.—*R. E. Thompson.* (*Courtesy Chem. Absts.*)